AD-A268 455

NRL/MR/7226--93-7193

The 1989 ONR Field Experiment: High Resolution Surfactant Film Measurements

R. D. Peltzer
O. M. Griffin
J. A. C. Kaiser
W. R. Barger

Remote Sensing Physics Branch
Remote Sensing Division

July 15, 1993

Approved for public release; distribution unlimited.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave Blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	July 15, 1993	Final 1 Jan 89 - 30 Sept. 92

4. TITLE AND SUBTITLE

The 1989 ONR Field Experiment: High Resolution Surfactant Film Measurements

5. FUNDING NUMBERS

PE - 0602111N
PR - RU11W71

6. AUTHOR(S)

R.D. Peltzer, O.M. Griffin, J.A.C. Kaiser, and W.R. Barger

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Naval Research Laboratory
Washington, DC 20375-5320

8. PERFORMING ORGANIZATION REPORT NUMBER

NRL/MR/7226--93-7193

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Office of Naval Research
800 North Quincy Street
Arlington, VA 22217-5660

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

Surface-active films are found in all geographic regions of the oceans. They are easily detected visually on the ocean surface when the wind speed is less than 10 knots (5.1 m/s). They are generally of biological origin and consist mainly of fulvic and hur acids, carbohydrates, proteins, and lipids. Surface-active films that become concentrated at the edges of the centerline wake generated by the passage of a surface ship strongly influence the propagation of the short gravity and capillary waves which interact with electromagnetic waves at both radar and visible wavelengths. An accurate method for detecting the presence of surface films and measuring the fine-scale surface film pressure and surface elasticity distributions on a water surface has been developed at the Naval Research Laboratory (NRL). A device for measuring the surfactant field was deployed during the 1989 ONR Field Experiment in order to measure the redistribution of the film material by the ship's passage. These measurements have led to a better understanding of the role these ship-generated surface-active film distributions play in the formation of the dark centerline wake and "railroad track" or dark line features which appear in synthetic aperture radar (SAR) images of ship wakes. These features are important factors to be considered in demonstrating the utility of the detection and classification of surface ships and their wakes using SAR from aircraft and satellites.

14. SUBJECT TERMS

Surface ship wakes   SAR imagery
Remote sensing
Ship wake hydrodynamics

15. NUMBER OF PAGES

127

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std 239-18
298-102

CONTENTS

ACKNOWLEDGEMENTS

This work was sponsored by the Surface Ship Wake Detection Project of the Applied Research and Technology Directorate (Code 1243) of the Office of Naval Research. Complementary support was provided by the Surface Ship Wake Consortium of ONR Code 1221. The authors are grateful to Dr. David H. Johnson, CAPT John G. Hughes and Mr. James A. Fein of ONR for their continued support of this work. The authors also are indebted to Prof. Jerome H. Milgram of MIT and Prof. Richard A. Skop of the University of Miami for their continuing collaboration with us at NRL on the problem of surface ship wake detection and classification. The contributions by Mr. James H. Lyden of the Environmental Research Institute of Michigan and by Dr. Dwight Hogge of Arete Associates who provided processed SAR images and data from the ONR experiment are greatly appreciated.

NOMENCLATURE

A	free surface area of surfactant film
a	surface wave height
B	ship beam
C	constant
c	wave phase speed
E_s	surface elasticity
Fr	Froude number, $V/(gL_{WL})^{0.5}$
g	gravitational acceleration
k	wavenumber
L, L_{WL}	ship length, waterline length
L_{WW}	length of the white water wake
n	logarithmic slope of pressure-area curve
n	propeller revolutions per second
S_{AW}	surface tension force at the air-water interface
S_{AO}	surface tension force at the air-oil interface
S_{OW}	surface tension force at the oil-water interface
V, V_s	ship speed
W	wake width
L-band	SAR operating frequency, 1.2 Ghz
C-band	SAR operating frequency, 5.3 Ghz
X-band	SAR operating frequency, 9.4 Ghz
α	surface tension of clean water
Π	surface film pressure
τ_{meas}	measured surface tension

THE 1989 ONR SHIP WAKE FIELD EXPERIMENT: HIGH-RESOLUTION SURFACTANT FILM MEASUREMENTS

1.0 INTRODUCTION

Full scale measurements and remote observations of surface ships for the purposes of ship wake detection and classification as in the 1989 ONR Field Experiment show the most ubiquitous and persistent wake feature to be a pair of bands of compacted surface-active material aligned with the ship track along the edges of the turbulent wake [*Peltzer et al.*, 1990, 1992; *Kaiser et al.*, 1988]. The bands are typically several to tens of meters wide and show a pronounced depression in surface tension. They typically appear as dark lines aligned at some narrow angle to the ship's path in synthetic aperture radar (SAR) images of ship wakes. Another prominent feature of the wake is a long, narrow region of relatively calm water behind the ship that is characterized by the absence of short wavelength waves. This region is commonly referred to as the "dead" water or centerline wake region. It is usually several ship beams in width and persists for many ship lengths astern of the ship. This region of relatively low radar backscatter is the most consistently seen wake manifestation in SAR images of ship wakes on the ocean surface [*Vesecky and Stewart*, 1982; *Lyden et al.*, 1988; *Reed et al.*, 1990; *Gasparovic and Johnson*, 1991; *Griffin et al.*, 1992].

Surface tension changes caused by the presence of surface-active films that have been concentrated at the edges of the centerline wake by the passage of the ship have been suggested as one of the physical mechanisms responsible for these SAR image features [*Peltzer et al.*, 1990, 1992]. Surfactant films strongly affect the propagation of the short gravity and capillary waves which interact with electromagnetic waves at both radar and visible wavelengths [*Huhnerfuss et al.*, 1981]. Surface tension and surface elasticity are the two major physical properties of surfactant films that contribute to short-wave damping. The persistence of these wake features and their contrast with the surrounding ocean surface depends upon the ship's speed, hull type, and propulsion system, as well as on the chemical and physical properties of the sea surface, air-sea dynamics and meteorological conditions.

Techniques are available to measure the mechanical properties, i.e., film pressure and surface elasticity, of surface-active ocean films. *Adam* [1937] was the first to use a series of bouyant calibrated oils to determine the surface tension of sea water in situ. When several oils are dropped onto the surface of the sea where a film of surface-active material may or may not be present, some will spread and others will not, and therefore the surface tension of the sea at the test point can be bracketed between the calibrated values of any two oils in the set. The resolution of the

Manuscript approved December 21, 1992.

surface tension measurement depends on the differences in the calibrated values of the test oils. The oils also must be dispensed rapidly and close together to identify fine structure in the surface tension gradients.

A towable, instrumented catamaran has been developed and deployed by NRL scientists to measure the cross-wake surface tension distribution after a ship's passage in order to investigate the physical origins of these bands of compacted surface-active material, and to provide the basis for predicting the signature of the wake for use in ship and ship wake detection and classification. This instrument package is named the Surface Tension Measuring System (STEMS). The device measures surface tension by dropping a sequence of calibrated spreading oils along a straight line on the water surface and recording their behavior with a video camera. This method provides the necessary spatial resolution to identify the fine structure in the surface tension gradients on the surface generated by the passage of a ship.

In this report we present a compilation of the cross-wake surface tension measurements that were obtained with STEMS during the field experiment conducted in January 1989 near Santa Cruz Island, California by the Surface Ship Wake Detection Project of the Office of Naval Research. One major objective of the ONR Surface Ship Wake Detection Project is to develop a validated capability to predict ship wake detectability for a wide range of ship classes and operating conditions in a realistic ocean environment. The experiment involved seven Navy combatants including a battleship, a cruiser, a destroyer, three frigates, and an auxiliary oiler. The site of the experiment afforded proximity to a land-based radar facility and an open ocean area suitable for the operation of an airborne SAR. An overview of the results obtained during the 1989 ONR experiment is given by *Gasparovic and Johnson* [1991].

The present program of wake measurement experiments was conducted to examine the influence of ship operating parameters and environmental conditions on the origin and persistence of these ship-generated surfactant bands. These cross-wake surface tension profiles, together with the surface film pressure-area and elasticity data also presented here, allow us for the first time to predict with some confidence the changes in wave energy due to these surfactants for a given radar wavelength band. To accomplish these predictions we have developed a model which uses the time series of surface tension together with the film pressure-area and elasticity data from a Langmuir trough, and the wind velocity and direction as inputs to compute cross-wake profiles

or two-dimensional maps of wave energy decay for a given radar wavelength. In a series of recent papers [*Peltzer et al.*, 1990, 1992; *Milgram et al.*, 1993*a,b*] the development of this model has been described, some results for wave energy decay obtained with the model have been presented for selected radar wavelengths, and these results have been compared to airborne SAR image intensity measurements obtained during the ONR experiment.

2.0 BACKGROUND

2.1. *Surface-Active Film Materials*

The surface-active (surfactant) materials that are found in all natural water bodies are chemicals which are by-products of plant and animal life. The term surfactant means that the long-chain carbon polar-organic chemicals which constitute these materials have a natural affinity for the free surface of the water in which they reside. Typically, the molecules have an acid, alcohol, ketone or other water-soluble radical on one end, which makes that end of the molecule hydrophilic. The opposite end is very similiar to a pure hydrocarbon, which is insoluble in water and is hydrophobic. Because of the polar nature of these substances, when they reach the water surface they find a preferred state in which the hydrophobic end of the molecule removes itself or sticks out from the water.

Surface-active materials have an affinity for the ocean surface. A small increase in the surface concentration of the materials at the interface can lead to significant capillary and small surface gravity wave ($\leq$ 20 cm wavelength) damping. When these surface-active materials are compacted, they form a surface-elastic film. A propagating wave alternately stretches and compresses the monomolecular film of material, which then decreases and increases the surface concentration. This process increases the surface tension in opposition to the wave propagation. Thus the viscous damping and viscoelastic damping are much higher than the viscous damping for a clean surface. Films can become concentrated enough to attenuate surface waves when they are compacted by horizontal convergences due to current field variations at the ocean surface. The currents that are most likely to compact the surfactant films within a ship's wake are the transverse currents generated by flow around the hull or currents associated with the breaking bow and stern waves.

Photographs of the surface wake [*Peltzer*, 1984] suggest that the surfactant material is being organized into these bands by rising bubbles generated in the breaking bow wave which then scavenge the surfactants from the water column. Surfactant material also can be transported rapidly to the water surface by adsorption at the air-water interface of rising bubbles generated by air entrainment around the ship's hull, in the breaking stern and shoulder waves and in the propeller wake flow. As these bubbles burst when they reach the air-water interface, the scavenged material is merged with that already adsorbed on the water surface [*Skop et al.*, 1991]. These bubbles are also concentrated by the horizontal convergences in the wake flow behind the ship; this is an additional mechanism which should enhance surfactant concentrations in the surface convergence zones. Surface velocity measurements [*Kaiser et al.*, 1988] suggest that a displacement hull sheds a pair of vortices which generate cross-wake surface currents, and, consequently, move any bubbles and surface-active materials present at the surface away from the center of the wake and toward the wake edges.

2.2. *Surface Ship Wake Hydrodynamics*

In this section we describe the wake of a surface ship in terms of the physical phenomena that are observed both visually and by means of various remote sensing systems, paying particular attention to those processes that modify the short surface waves in the wake. A photograph of a prototypical surface ship wake is shown in Figure 1. The wake is composed of white water, the viscous or turbulent wake, the propeller wake, and the Kelvin wake. The white water generally originates at the bow, is reinforced at the stern, and extends aft of the ship for several ship lengths. The viscous wake extends many ship lengths aft from the stern of the ship and incorporates the flow moving in the direction of the ship's travel due to the viscous drag, as well as large-scale vortical flows and turbulence. Embedded within the viscous wake is the propeller outflow or propeller wake. Superimposed over this is the classical Kelvin wave pattern or Kelvin wake. The Kelvin wake is also the source of many of the viscous wake manifestations. It is in fact the breaking bow and stern waves from the Kelvin wave system that contribute significantly to the white water regions at the bow and stern. Interactions between the Kelvin wave system and the ambient surface wave field generate steepening and breaking events at all wavelength scales. These wake manifestations lie upon the ambient seaway made up of swell, wind waves, and short gravity and

Figure 1. Photograph of the near-field wake of a surface ship.

capillary waves, all of which confuse the picture even more. *Reed et al.* [1990] have presented an extensive discussion of the hydrodynamics of remotely sensed surface ship wakes, and the reader is referred to that paper for further information on that particular topic.

When describing the processes that influence short waves in the wake, it is useful to separate the wake into two distinct regions. The near-field wake region extends several ship beams off to each side of the ship and approximately six to eight ship lengths aft of the ship, and the region that extends further aft is the far-field wake. The near-field wake can be thought of as the region where surface foam, subsurface bubbles, strong transverse and axial currents, and strong turbulence and vorticity are generated and where the most rapid changes in these features occur. The short waves are scattered to different wave numbers by the currents, vorticity, and turbulence in this region in addition to being diffracted by the strong mean currents [*Phillips,* 1958; *Skop et al.,* 1990]. The turbulence also extracts significant energy from the short waves [*Olmez and Milgram,* 1990; *Kitaigorodskii and Lumley,* 1983]. Rising bubble plumes also generate turbulence and surface currents in addition to scavenging surface-active materials to the surface from within the water column. At the edges of the wake there are velocity convergence zones where the strong transverse currents merge with the relatively stationary ambient water. The surface-active material on the surface is redistributed by the currents and concentrated in these convergence zones [*Peltzer et al.,* 1990]. The short waves can be significantly attenuated in these regions of increased surface concentration [*Garrett,* 1967; *Dorrestein,* 1951].

In the near-field wake, an initial region of the viscous and propeller wakes is a region of high angular divergence of foamy, turbulent, white water directly aft of the ship's stern, generally outlined by what appears to be a spilling-type breaking stern wave (see the photograph in Figure 1). There are several additional sources of highly energetic white water and turbulence in the near-field wake. The bow and shoulder waves that are generated by the ship's motion break, producing white water and turbulence when the wave steepness ak (where a is wave amplitude and k is wave number), is greater than about $ak = 0.30$ [*Ramberg and Griffin,* 1987; *Bonmarin,* 1989]. The region adjacent to the ship's hull produces foam, bubbles and turbulence because of the frictional drag forces at the surface of the hull. A recent photographic analysis by *Peltzer* [1984] developed empirical relations for the length (L_{WW}) of the foamy white water region. These empirical relations indicate that the length of the white water region is a function of the Froude

number ($Fr = V_S/(gL_{WL})^{0.5}$, where V_S is the ship speed, g is the gravitational acceleration, and L_{WL} is the waterline length) or the ship's propeller revolutions per second (n). Energy input to the short waves by the wind in the near-field wake is small compared to their dissipation by the highly energetic turbulence.

The far-field wake is that region where the variations in the foam, viscous, propeller, turbulence, and vortical features of the wake decay are relatively slow. Wind-induced short-wave growth [*Plant*, 1982; *Mitsuyasu and Honda*, 1982] and nonlinear wave/short wave interactions [*Hasselmann*, 1962] become dominant in the modified wave field in the far-field wake, although there is still some weak turbulence/short wave interaction. Consequently, the surface roughness characteristics gradually return to those of the surrounding ambient surface. Measurements have shown that subsurface bubble wakes can persist for an hour or more after the passage of a ship [*National Defense Research Committee*, 1946]. This implies that there may still be some continued scavenging of surface-active materials by the rising bubbles. Weak transverse currents generated by a pair of bilge vortices in some instances may continue to redistribute and compact the surfactant materials within the wake. The bands of redistributed surfactant material created by the wake flows are highly persistent and continue to damp the short waves as they propagate through the bands. Significantly more energy is extracted from the waves than is input by the wind and nonlinear interactions in these bands.

2.3. Remote Sensing Applications

Remote sensing of these ship-generated surfactant bands with a SAR depends on the interaction of the electromagnetic waves with the Bragg-resonant short waves in the region of the bands. The physicochemical properties of the surfactant films in these bands attenuate the short waves and also block their formation or reformation by wind. The damping of these short waves reduces the Bragg scattering in the films compared with that of the surrounding clean water, and the film bands appear dark in SAR images. These films can reduce the radar cross section of the surface by as much as 15 dB depending on the concentration and elastic properties of the film and on the radar wavelength. In sunglint images, the surfactant films appear as bright, double bands. In light to moderate winds ($<$ 6 knots or 3 m/s) these surfactant films are highly persistent.

An example of the reduced radar return in the centerline wake is shown in Figure 2 which is an airborne SAR image obtained during one of the runs of the ONR experiment near Santa Cruz Island. Figure 3 is an aerial photograph of the surface wake pattern taken 100 minutes after a Navy ship passed by during one of the experimental runs. The dark lines outlining the edges of the wake are ship-generated bands of compacted surfactant material. The surfactants in these bands have completely damped the short waves and have eliminated specular reflections of the sunlight in these regions.

3.0 SURFACTANT FILM MEASUREMENTS

3.1. *Surface Tension Measurement by Spreading Oils*

Several techniques have been proposed to measure the mechanical properties of ocean surfactant films in situ (e.g., capillary wave damping, laser second-harmonic generation, and spreading oils), but only the use of spreading oils has been successful thus far. *Adam* [1937] was the first to use a series of buoyant calibrated oils to determine the surface tension of sea water in situ. More recently, this technique has been described by *Garrett and Duce* [1980]. When several oils are dropped onto the surface of the sea where a film of surface-active material may or may not be present, some will spread, while others will not, and therefore the surface tension of the sea at the test point can be bracketed between the calibrated values of any two oils in the set. Figure 4 illustrates a spreading oil (Figure 4*a*) and a nonspreading oil (Figure 4*b*) on the water surface. The straight white lines are toothpicks that were used to apply the oils to the surface. The resolution of the surface tension measurements depends on the differences in the calibrated values of the test oils. The oils must also be dispensed rapidly and close together to identify fine structure in the surface tension gradients. For the 1989 Field Experiment we refined this technique to provide the necessary spatial resolution and prepared a set of 23 spreading oils to cover the surface tension range from 44 to 73 mN/m. The preparation and calibration of these oils and the principle by which these oils work is described below.

The spreading oils were made from a pure nonspreading paraffin oil into which precisely controlled trace quantities of a pure surface-active compound, dodecanol, were dissolved. Different batches of commercially available paraffin oil already contain traces of surface-active components, so each set of spreading oils must be calibrated – they cannot be made reliably by following the

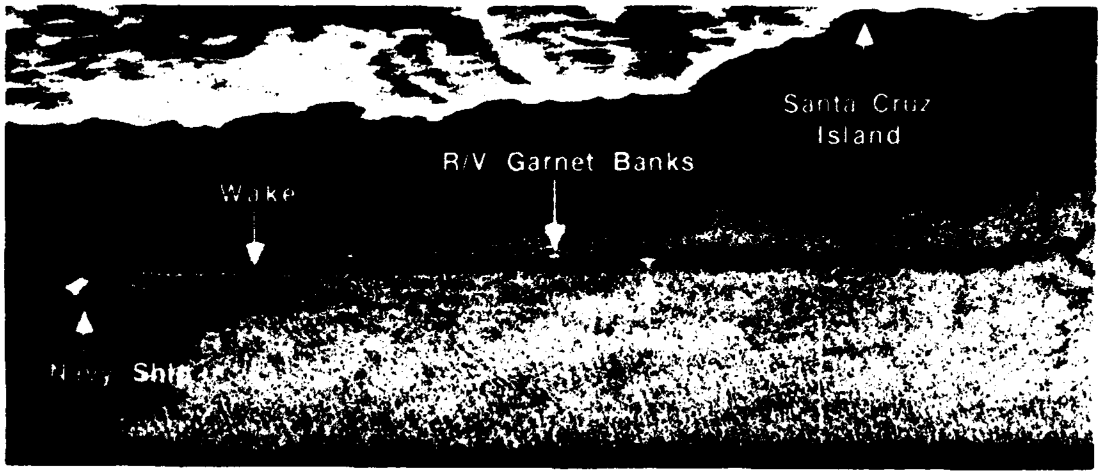
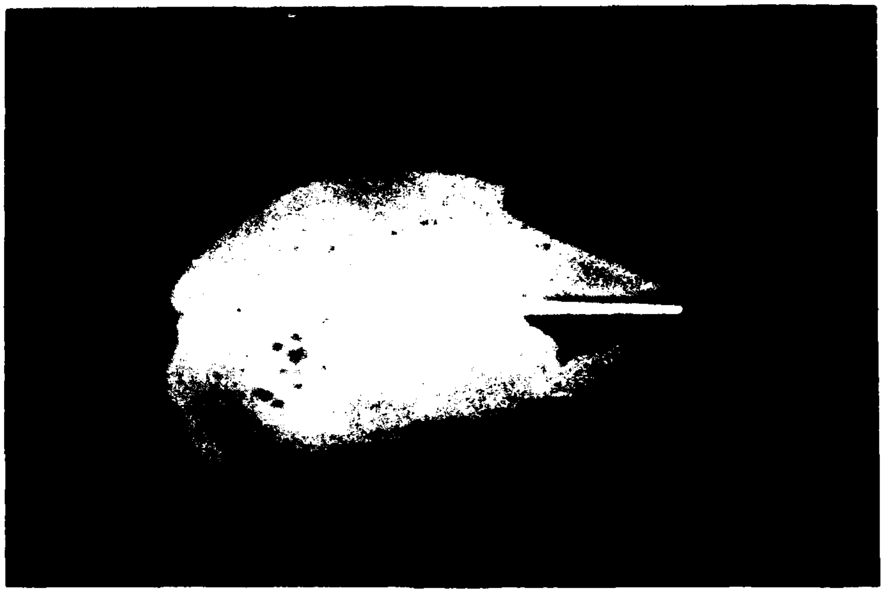
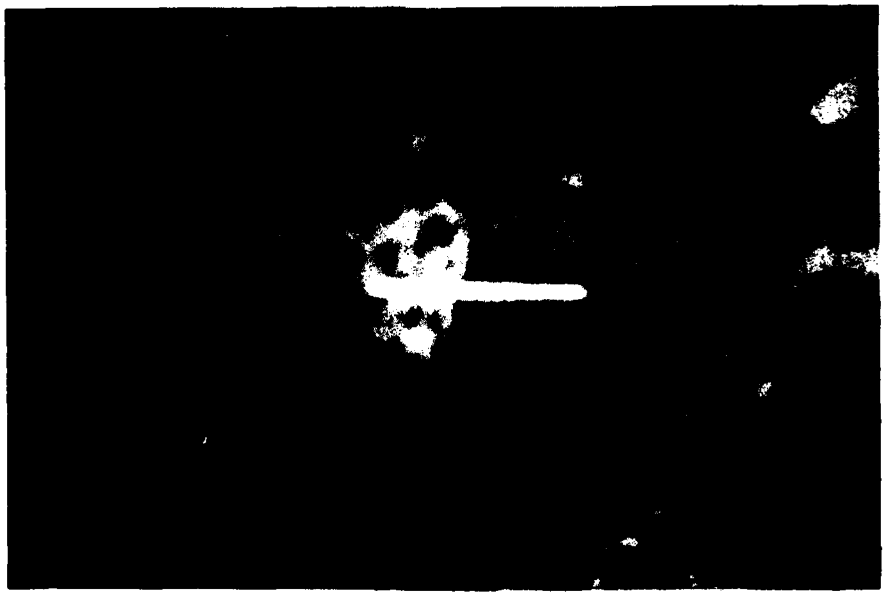


Figure 2. L-band airborne SAR image of the Navy destroyer during the 1989 ONR Field Experiment. The ship speed is 25 knots, or 12.9 m/s. (Courtesy of J. Lyden, ERIM.)

Figure 3. Photograph of the surface wake pattern 100 min after the passage of a Navy ship during the 1989 ONR Field Experiment.



a) Spreading Oil



b) Non-Spreading Oil

Figure 4. Video image of (*a*) spreading and (*b*) nonspreading oil distribution.

approach employed for an earlier set. Calibrations were carried out using the Langmuir trough facility of the NRL Chemistry Division and can be more easily discussed in terms in terms of film pressures. Film pressure (Π) is defined as the difference in surface tension calculated by subtracting the surface tension of water covered by a film (τ_{meas}) from the surface tension of clean water (α), or $\Pi = \alpha - \tau_{\mathrm{meas}}$.

The surface tension (and therefore the film pressure) was varied in the Langmuir trough instrument by compressing or expanding a monolayer film of oleyl alcohol surrounding the oil to be calibrated. The plateau film pressure (at which the oil drop had expanded to a thin disc that could be varied in diameter by expanding or compressing the monolayer while still maintaining a constant film pressure) was the assigned equilibrium spreading pressure (ESP) of the oil. For oil drops of approximately 20 mg the diameter was approximately 3 cm at the ESP value.

The principle by which these oils work is illustrated in Figure 5. S_{AW} is the surface tension at the air-water interface, S_{AO} is the surface tension at the air-oil interface, and S_{OW} is the oil-water interfacial tension. Since S_{AO} and S_{OW} are reduced by adding a surface-active compound to the paraffin oil, a series of oils with varying spreading characteristics can be prepared. If $S_{AW} > (S_{AO}\cos A + S_{OW}\cos B)$, the oil will spread. Organic surface-active films on water will reduce S_{AW}. As the oil becomes thinner by spreading, both $\cos A$ and $\cos B$ approach the value of unity, and the force balance required for continued spreading becomes $S_{AW} > (S_{AO} + S_{OW})$. When the colorless oil spreads to a thickness in the 500 to 700 nm range, interference colors can be observed visually from a distance. To make a measurement, oils with progressively higher concentrations of dodecanol are dropped onto the surface until one is observed to spread.

The resolution of the measurement in surface tension depends on the ambient surface tension. Table 1 gives the spreading pressures for the 23 oils used in the Field Experiment. The resolution is nominally the difference in pressure between adjacent oils, which is tabulated in column 3 of Table 1. Note that at high surface tensions (near the clean water values) the resolution is nearly 0.16 mN/m, but reduces to several milliNewtons per meter at very low surface tensions. The spreading pressures were intentionally graduated this way to optimize the resolution of the measurement to the physical processes involved.

3.2. *Determination of Physicochemical Properties*

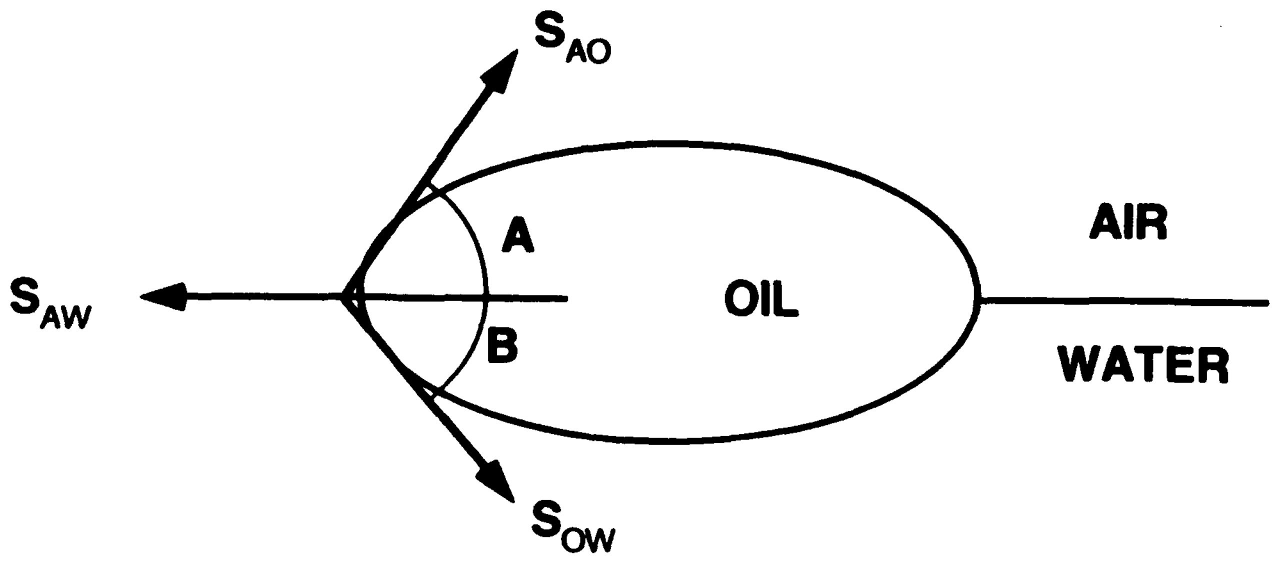


Figure 5. Balance of forces acting on an oil drop.

TABLE 1. Spreading Oils

Oil Number	Surface Tension	Difference
1	73.03	0.16
2	72.87	0.15
3	72.72	0.16
4	72.56	0.16
5	72.40	0.14
6	72.26	0.18
7	72.08	0.16
8	71.92	0.16
9	71.76	0.13
10	71.63	0.28
11	71.35	0.34
12	71.01	0.17
13	70.84	0.31
14	70.53	0.53
15	70.00	0.67
16	69.33	0.62
17	68.71	2.09
18	66.62	1.99
19	64.63	2.64
20	61.99	1.17
21	60.82	7.42
22	53.40	8.85
23	44.55	

The important property of a surfactant film which governs the wave damping is its elasticity E_s. However, we did not measure this in situ but determined it indirectly as follows.

We collected samples of water during the experiment and then transported them back to NRL for measurement in the Chemistry Division's Langmuir trough. The measurement consists of determining the pressure-area relationship for the surfactant, from which its elastic properties are calculated. This procedure is described in detail by *Barger and Means* [1985] and is outlined here. The surfactant material in the sample adsorbs to the surface in a few hours and forms a thin film. The free surface area (A) containing the film is decreased slowly by moving a barrier along the surface as the surface tension τ_{meas} is measured with a Wilhelmy plate. The Wilhelmy plate technique uses a flame-cleaned thin platinum plate which is held over the filmed water surface. It is carefully and slowly brought into contact with the film and a meniscus forms which then exerts a downward force on the plate. The surface tension force is measured with a strain gauge, and the system is carefully calibrated against known liquids. This procedure generates the function $\tau(A)$. The measured surface tension τ_{meas} is related to the underlying clean water surface tension (α) and the pressure Π exerted by the surfactant film by the relation

$$\tau_{\mathrm{meas}} = \alpha - \Pi. \tag{1}$$

The elasticity of the film is defined as

$$E_s = -A\frac{d\Pi}{dA} = -\frac{d\Pi}{d(lnA)}. \tag{2}$$

Thus by taking the negative of the logarithmic slope of the $\Pi(A)$ curve measured in the Langmuir trough, we obtain the function $E_s(A)$. From the measured $\Pi(A)$ relation we then obtain

$$E_s = E_s(\Pi), \tag{3}$$

since both $E_s(A)$ and $\Pi(A)$ are single valued over the range of values of Π encountered in the Field Experiment (0 to 30 mN/m).

In order to determine the elasticity E_s by this method we make the assumption that the surfactant material adsorbing at the surface of the water sample in the laboratory has the same physical properties as that which had adsorbed on the sea surface. Hundreds of film samples collected by various techniques, including screens and rotating glass drums which sample a layer of the order of microns near the surface, have shown remarkably similar pressure-area relations [*Barger and Means*, 1985; *Barger et al.*, 1988]. In addition, surface chemists define the reciprocal of the elasticity as the coefficient of compressibility. Compressibility measurements for 52 film samples from Atlantic surface, bulk, and deep water and Chesapeake Bay water are reported by *Barger and Means* [1985] and also show remarkable similarities in behavior.

However, there is the possibility that mechanical and chemical reactions occur on the ocean surface which may alter the mechanical properties of the surfactant film. The two most likely possibilities are photochemical reactions due to the ultraviolet component of the solar spectrum and working of the film due to the continual compaction and expansion caused by the passage of surface waves. Furthermore, in calm conditions the surface constituents may not have the same relative concentrations as those in the sampled water column. At present there is little or no evidence to address these issues, so we are reasonably confident in the relationship given by equation (3) to determine the elasticity of films on the the ocean surface.

3.3. *The Surface TEnsion Measurment System (STEMS)*

STEMS is a small catamaran which is towed by a host vessel from a boom off the forward port side of the vessel. The *R/V Garnet Banks*, an ex-Navy YTB class tug, was the vessel employed during the 1989 ONR Field Experiment. A photograph of STEMS taken during its deployment is shown in Figure 6. In this configuration it is 2 m wide, 3 m long, and weighs approximately 135 kg. The photograph shows the STEMS as it is being towed at one knot (0.5 m/s) through a compacted surfactant film band at the edge of a Navy ship wake. The smoke flare was used to mark the location of the edge of the wake during the experiment. Note the absence of short waves in the film band compared with the water surface outside the band. Figure 7*a* shows the towing configuration employed in the ONR experiment. The STEMS needs to be outside of any disturbance created by the host vessel, so it has a movable rudder to control its distance away from the towing vessel. In all cases it must sample an undisturbed water surface. Maximum tow

Surface TEnsion Measurement System (STEMS)

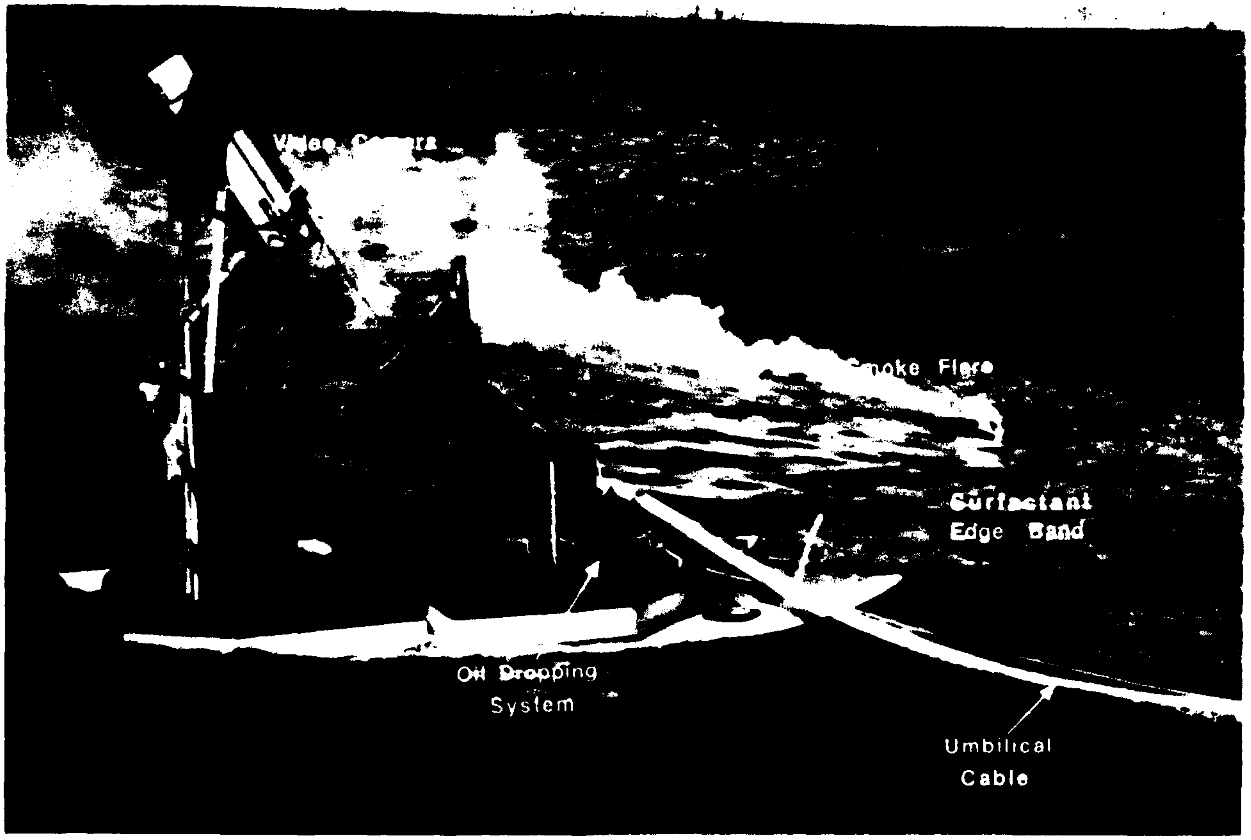
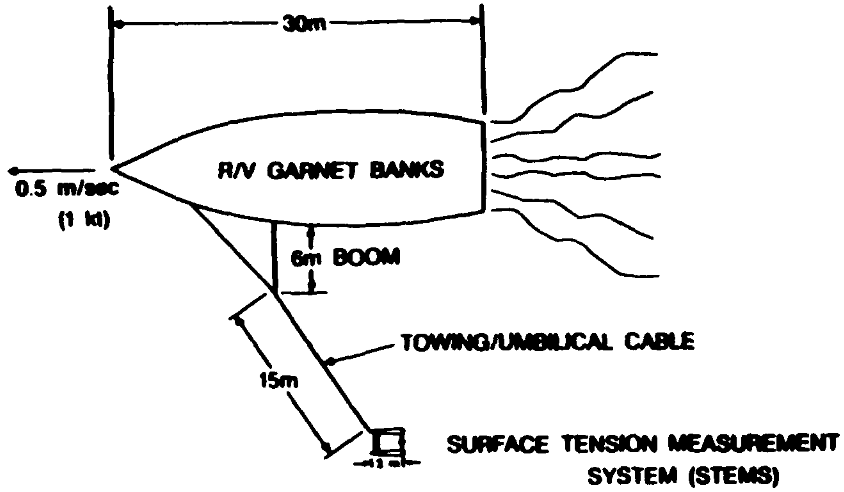
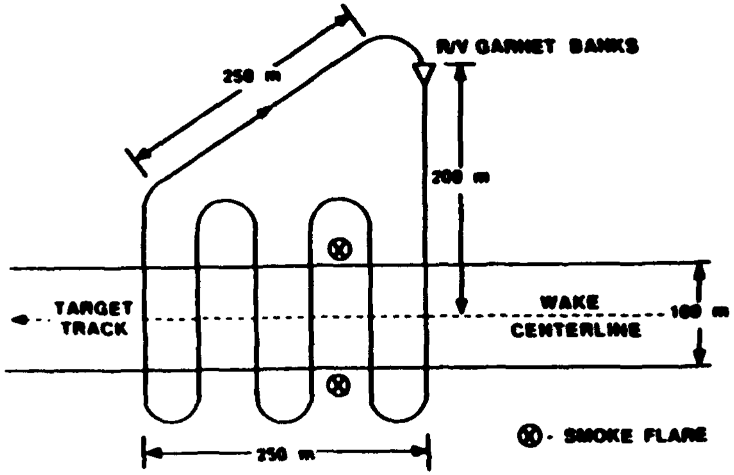


Figure 6. Photograph of the Surface Tension Measuring System (STEMS) as it is being towed at one knot (0.5 m/s) through a compacted surfactant film band at the edge of a Navy surface ship wake.



a. Towing Configuration



b. Wake Crossing Pattern

Figure 7. (*a*) Towing configuration and (*b*) wake crossing pattern employed to measure the surface tension profiles across the wakes of Navy ships with STEMS during the 1989 ONR Field Experiment.

speed depends on sea conditions and wind, but generally a tow speed of one knot (0.5 m/s) was found to give reliable performance of STEMS.

3.4. Operations Using STEMS

For the operations during the ONR experiment we positioned the R/V *Garnet Banks* either north or south of the wake produced by the passing Navy ship, about 100 to 200 m off-track before the scheduled start of the individual test runs. As the Navy ship approached, we moved toward its track and towed STEMS across the wake, intending to follow the serpentine pattern shown in Figure 7*b*. Our tow speed was about one knot (0.5 m/s), so that in the time allocated for each run (approximately 50 min) we could only make three to four wake crossings. If the sea became too rough, turbulence and splashing within STEMS made observation of the spreading oil behavior difficult to impossible.

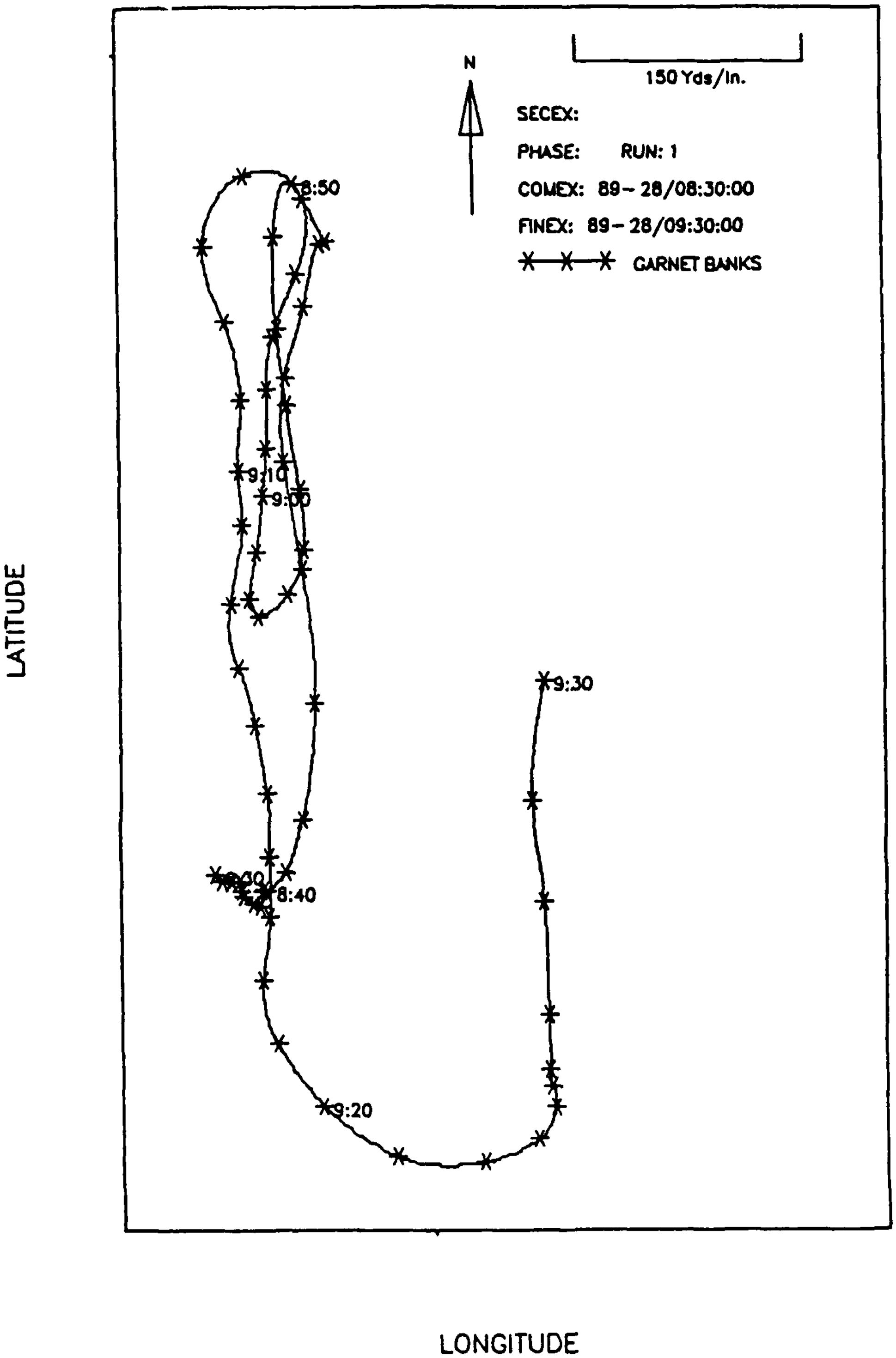
The device measures the surface tension in situ by dropping 22 calibrated spreading oils on the water surface from individually regulated channels. Each oil represents one surface tension value, so if one oil spreads and the next one does not, the in situ surface tension is bracketed between the values of the two spreading oils. In some cases a drop of oil will neither spread nor not spread, but will oscillate instead. Presumably its spreading pressure is almost exactly the value of the surfactant film and the oscillation occurs because the ambient surface tension oscillates about a mean value due to alternate surface compactions and expansions induced by the passage of surface waves. The dropping of each individual oil is controlled from the ship, and a permanent video record of its spreading behavior is obtained for later analysis.

One reading of surface tension was typically obtained every 1 to 2 s when the winds were under 5.5 m/s, and less frequently for higher wind speeds. This gave a cross-wake resolution of 0.5 to 1.0 m in the lighter-wind runs. The down-wake resolution was highly variable but averaged 50 m. The resolution in surface tension varied from 0.16 mN/m to a few millinewtons per meter based on the differences in spreading pressures of the oils (see Table 1). Through the first 9 days of the Field Experiment (January 23 to January 31), the oil number in the table corresponded directly to the channel number on the STEMS. Channels 5 and 8 did not work throughout the entire test, and channel 22 worked only on the final 2 days of the Field Experiment (January 31 and February 1). Oil 23 was used on the final day of the test (February 1) in place of oil 1. It was unfortunate

that oils 22 and 23 were not working or available during most of the Field Experiment, because we could not establish the maximum value of the surface tension decrease in certain regions of both the ship generated and ambient surfactant bands. If we assume that the physical properties of the compacted surfactant material in the bands were similar throughout the Field Experiment, we know that the maximum surface tension decrease in the bands varied between our measured value of 11.3 mN/m and some value greater than 27.2 mN/m. There were regions where oils 21, 22, and 23 did not spread when they were used on the final day (February 1) of the Field Experiment, and in addition, oils 21 and 22 did not spread during portions of the measurements on January 31. All of the film pressure - area curves we have examined so far (January 26, 28, 29) have similar characteristics, which suggests that the physical properties of the surfactant films are indeed similar on a day to day basis. Furthermore, measurements of surface film pressures of surface-active organic matter generated by marine phytoplankton typically range between 20 mN/m and 30 mN/m [*Frew et al.,* 1990]. Considering all of the above, we can confidently assume that the maximum surface film pressure in the film bands varied somewhere between 11.3 mN/m and 30 mN/m.

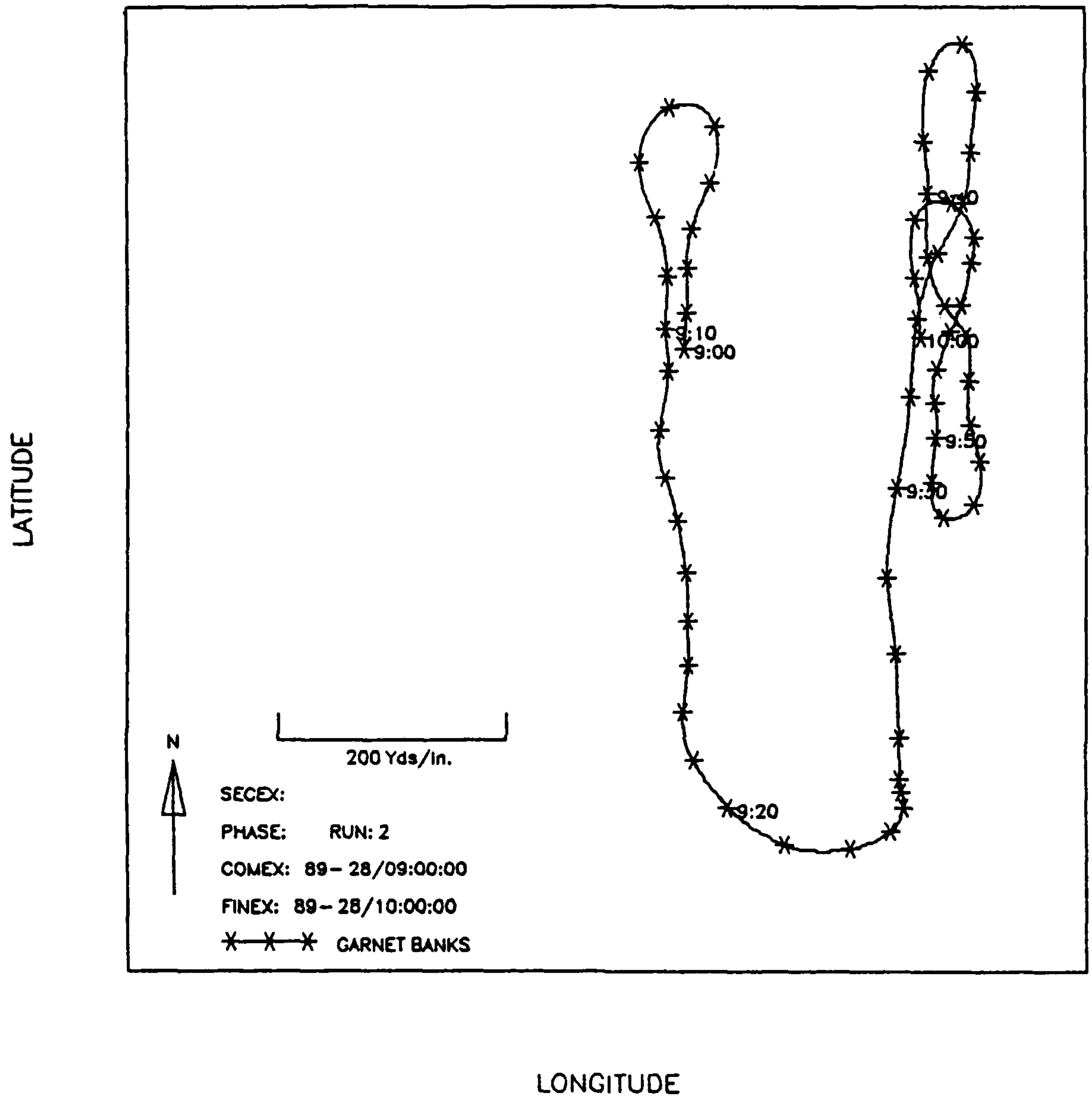
3.5. PMTC Tracking Data Plots and STEMS Velocity Histories

The PMTC tracking data plots showing the location of the R/V Garnet Banks (and the towed STEMS) in one minute intervals during the Runs were provided to NRL by the Johns Hopkins University Applied Physics Laboratory (JHUAPL). Figures 8 through 11 show the PMTC tracking plots of the STEMS location during Runs 1, 2, 3, and 4 on Jan. 28, 1989. The procedure used to obtain the velocity of the STEMS from the plots during these one minute intervals was fairly simple. Tables 2 through 5 contain the tabulated velocities of the STEMS during these four Runs. The physical distances between the minute markers (times listed in column 2) on the plots were measured with a ruler and/or plan measure and tabulated. With the inches to meters scale provided on the plots, the conversion of these distance values to velocity values (X meters travelled in 60 seconds) was direct (velocities listed in column seven). Any deviation of the STEMS heading from true north or south were measured (column six) and the velocities were then adjusted to reflect these differences (column five). An estimate of the ambient surface drift velocity of the wake was then made by measuring the relative displacement of the wake centerline from the



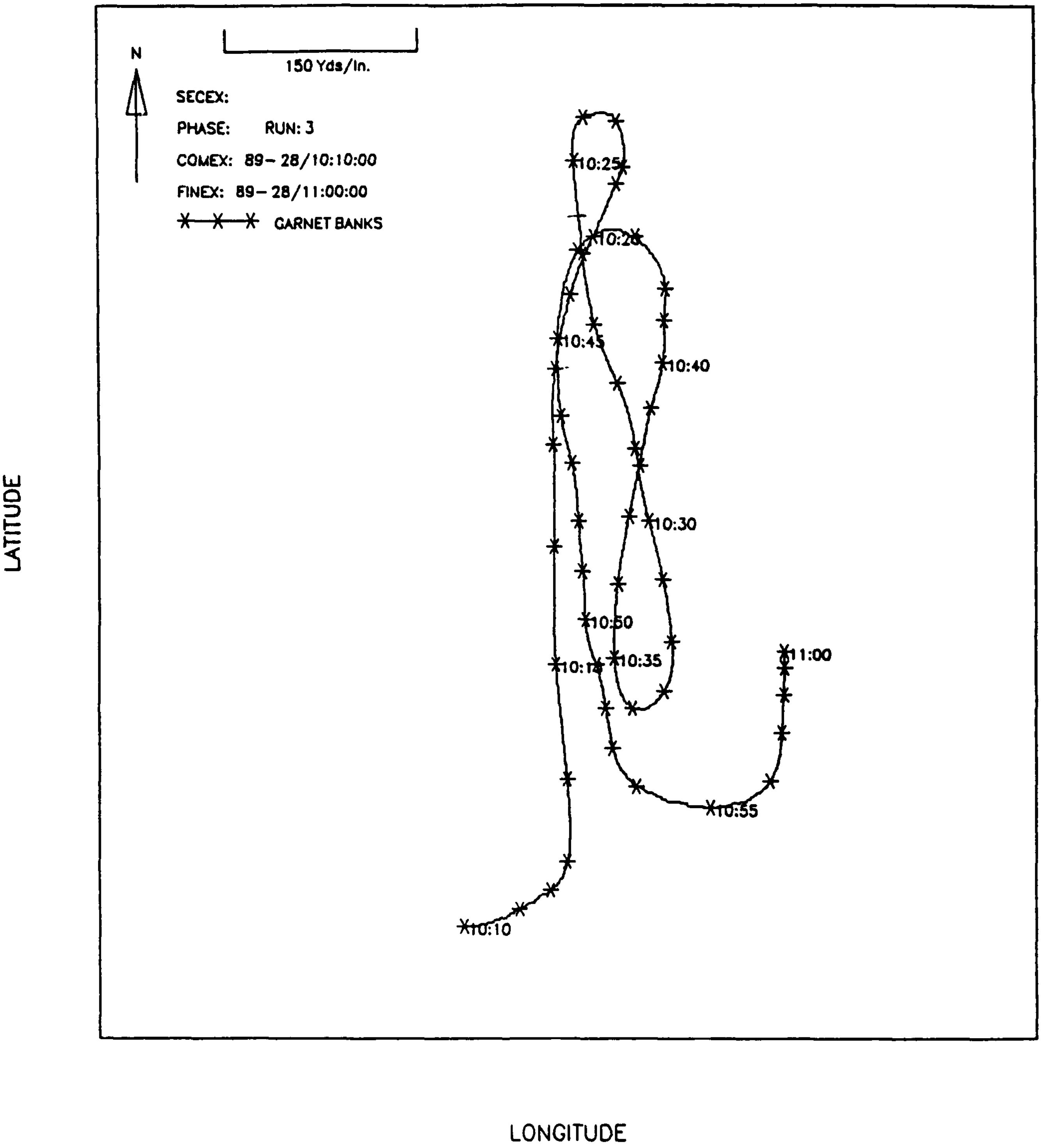
STEMS Location, Jan. 28, 1989, Run 1, Legs 1, 2, 3, 4, Ship Speed = 12 kts

Figure 8. PMTC tracking plot of the STEMS location during Run 1 on January 28, 1989.



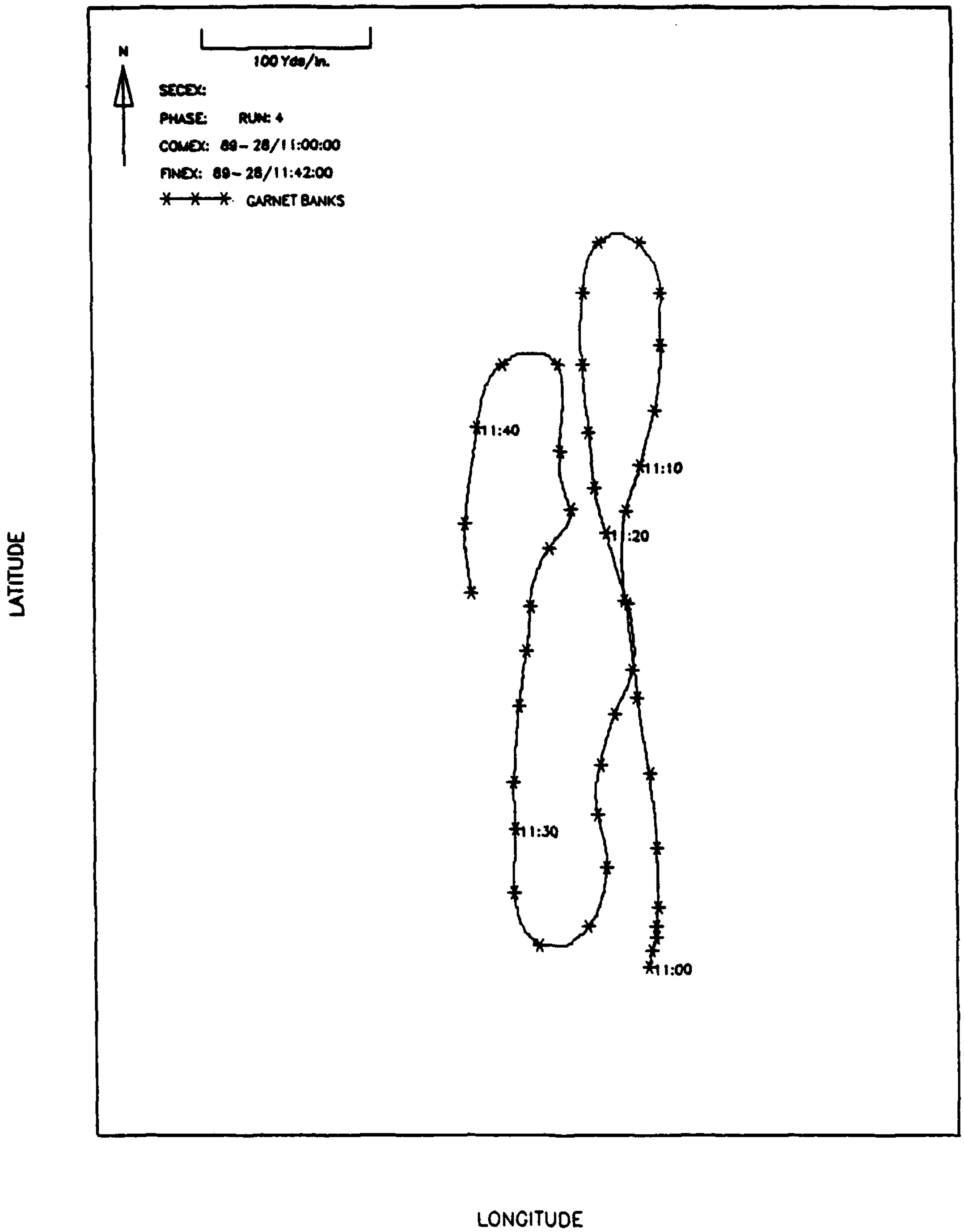
STEMS Location, Jan. 28, 1989, Run 2, Legs 1, 2, 3, Ship Speed = 25 kts

Figure 9. PMTC tracking plot of the STEMS location during Run 2 on January 28, 1989.



STEMS Location, Jan. 28, 1989, Run 3, Legs 1, 2, 3, 4, Ship Speed = 18 kts

Figure 10. PMTC tracking plot of the STEMS location during Run 3 on January 28, 1989.



STEMS Location, Jan. 28, 1989, Run 4, Legs 1, 2, 3, Ship Speed = 25 kts

Figure 11. PMTC tracking plot of the STEMS location during Run 4 on January 28, 1989.

TABLE 2. STEMS velocities during Run 1

Jan 28, 1989 Run 1	Local Time	Velocity (m/s)	Surface Wake Drift Velocity (m/s)	Velocity Corr. for Heading (m/s)	Heading Deviation from 0,180 degrees (PMTC)	Original Velocity (m/s) (PMTC)
Jan 28	8:45-8:46	0.931	0.070	0.861	0.0	0.861
Run 1	8:46-8:47	0.804	0.070	0.734	15.0	0.759
Leg 1	8:47-8:48	0.688	0.070	0.618	16.0	0.624
	8:48-8:49	0.668	0.070	0.618	16.0	0.624
Jan 28	8:51-8:52	0.912	0.030	0.942	0.0	0.951
Run 1	8:52-8:53	0.728	0.030	0.758	8.0	0.759
Leg 2	8:53-8:54	0.822	0.030	0.852	9.0	0.861
	8:54-8:55	0.590	0.030	0.620	3.0	0.642
Jan 28	8:57-8:58	0.230	0.050	0.180	30.0	0.208
Run 1	8:58-8:59	0.522	0.050	0.472	10.0	0.477
Leg 3	8:59-9:00	0.623	0.050	0.573	5.0	0.579
	9:00-9:01	0.526	0.050	0.476	5.0	0.477
	9:01-9:02	0.652	0.050	0.602	0.0	0.609
	9:02-9:03	0.600	0.050	0.550	5.0	0.564
Jan 28	9:08-9:09	0.733	0.050	0.783	13.0	0.801
Run 1	9:09-9:10	0.672	0.050	0.722	0.0	0.729
Leg 4	9:10-9:11	0.505	0.050	0.555	0.0	0.564
	9:11-9:12	0.745	0.050	0.795	7.0	0.801
	9:12-9:13	0.596	0.050	0.646	6.0	0.654
	9:13-9:14	0.534	0.050	0.584	15.0	0.609
	9:14-9:15	0.630	0.050	0.680	10.0	0.683
	9:15-9:16	0.591	0.050	0.641	0.0	0.638
	9:16-9:17	0.548	0.050	0.598	0.0	0.594

TABLE 3. STEMS velocities during Run 2

Jan 28, 1989 Run 2	Local Time	Velocity (m/s)	Surface Wake Drift Velocity (m/s)	Velocity Corr. for Heading (m/s)	Heading Deviation from 0,180 degrees (PMTC)	Original Velocity (m/s) (PMTC)
Jan 28	9:31-9:32	1.054	0.00	1.054	6.0	1.083
Run 2	9:32-9:33	0.868	0.00	0.868	21.0	0.941
Leg 1	9:33-9:34	0.668	0.00	0.668	27.0	0.762
	9:34-9:35	0.680	0.00	0.680	10.0	0.702
	9:35-9:36	0.825	0.00	0.825	8.0	0.842
	9:36-9:37	0.648	0.00	0.648	16.0	0.682
Jan 28	9:39-9:40	0.558	0.150	0.708	4.0	0.722
Run 2	9:40-9:41	0.694	0.150	0.844	0.0	0.842
Leg 2	9:41-9:42	0.405	0.150	0.555	20.0	0.702
	9:42-9:43	0.243	0.150	0.393	38.0	0.502
	9:43-9:44	0.470	0.150	0.620	4.0	0.621
	9:44-9:45	0.446	0.150	0.596	0.0	0.601
	9:45-9:46	0.338	0.150	0.488	17.0	0.521
Jan 28	9:49-9:50	0.677	0.080	0.597	5.0	0.601
Run 2	9:50-9:51	0.552	0.080	0.472	0.0	0.481
Leg 3	9:51-9:52	0.534	0.080	0.454	0.0	0.461
	9:52-9:53	0.587	0.080	0.507	21.0	0.541
	9:53-9:54	0.444	0.080	0.364	23.0	0.401
	9:54-9:55	0.641	0.080	0.561	15.0	0.581

TABLE 4. STEMS velocities during Run 3

Jan 28, 1989 Run 3	Local Time	Velocity (m/s)	Surface Wake Drift Velocity (m/s)	Velocity Corr. for Heading (m/s)	Heading Deviation from 0,180 degrees (PMTC)	Original Velocity (m/s) (PMTC)
Jan 28	10:18-10:19	0.945	0.056	0.889	11.0	0.915
Run 3	10:19-10:20	0.755	0.056	0.699	20.0	0.755
Leg 1	10:20-10:21	0.681	0.056	0.625	23.0	0.679
	10:21-10:22	0.256	0.056	0.200	23.0	0.214
	10:22-10:23	0.606	0.056	0.550	8.0	0.558
Jan 28	10:25-10:26	0.980	0.130	1.110	6.0	1.121
Run 3	10:26-10:27	0.700	0.130	0.830	11.0	0.848
Leg 2	10:27-10:28	0.571	0.130	0.701	22.0	0.763
	10:28-10:29	0.649	0.130	0.779	15.0	0.799
	10:29-10:30	0.719	0.130	0.849	13.0	0.875
	10:30-10:31	0.571	0.130	0.701	11.0	0.719
	10:31-10:32	0.601	0.130	0.731	11.0	0.741
Jan 28	10:36-10:37	0.969	0.167	0.802	11.0	0.822
Run 3	10:37-10:38	0.769	0.167	0.602	11.0	0.612
Leg 3	10:38-10:39	0.855	0.167	0.688	11.0	0.701
	10:39-10:40	0.715	0.167	0.548	11.0	0.558
	10:40-10:41	0.671	0.167	0.504	0.0	0.505
	10:41-10:42	0.540	0.167	0.373	0.0	0.375
Jan 28	10:45-10:46	0.843	0.090	0.933	0.0	0.933
Run 3	10:46-10:47	0.475	0.090	0.565	12.0	0.580
Leg 4	10:47-10:48	0.590	0.090	0.680	8.0	0.688
	10:48-10:49	0.507	0.090	0.597	4.0	0.603
	10:49-10:50	0.479	0.090	0.569	4.0	0.571
	10:50-10:51	0.455	0.090	0.545	12.0	0.563
	10:51-10:52	0.424	0.090	0.514	12.0	0.522
	10:52-10:53	0.378	0.090	0.468	12.0	0.478

TABLE 5. STEMS velocities during Run 4

Jan 28, 1989 Run 4	Local Time	Velocity (m/s)	Surface Wake Drift Velocity (m/s)	Velocity Corr. for Heading (m/s)	Heading Deviation from 0,180 degrees (PMTC)	Original Velocity (m/s) (PMTC)
Jan 28	11:06-11:07	0.820	0.140	8.0	0.680	0.691
Run 4	11:07-11:08	1.001	0.140	8.0	0.861	0.881
Leg 1	11:08-11:09	0.940	0.140	0.0	0.800	0.804
	11:09-11:10	0.549	0.140	17.0	0.409	0.432
	11:10-11:11	0.628	0.140	17.0	0.488	0.512
	11:11-11:12	0.729	0.140	5.0	0.589	0.589
	11:12-11:13	0.612	0.140	0.0	0.472	0.476
Jan 28	11:17-11:18	0.533	0.075	5.0	0.608	0.613
Run 4	11:18-11:19	0.463	0.075	5.0	0.538	0.509
Leg 2	11:19-11:20	0.321	0.075	15.0	0.396	0.414
	11:20-11:21	0.559	0.075	15.0	0.634	0.655
	11:21-11:22	0.518	0.075	4.0	0.593	0.595
	11:22-11:23	0.318	0.075	22.0	0.393	0.429
	11:23-11:24	0.386	0.075	16.0	0.461	0.479
	11:24-11:25	0.370	0.075	4.0	0.445	0.446
	11:25-11:26	0.399	0.075	9.0	0.474	0.479
Jan 28	11:29-11:30	0.659	0.090	0.0	0.569	0.568
Run 4	11:30-11:31	0.509	0.090	0.0	0.419	0.417
Leg 3	11:31-11:32	0.775	0.090	3.0	0.685	0.685
	11:32-11:33	0.584	0.090	8.0	0.494	0.497
	11:33-11:34	0.490	0.090	8.0	0.400	0.408
	11:34-11:35	0.600	0.090	20.0	0.510	0.542
	11:35-11:36	0.449	0.090	28.0	0.359	0.408
	11:36-11:37	0.611	0.090	11.0	0.521	0.533

original track during the Run. The final estimate of the STEMS velocity after these corrections were applied are listed in column three. The largest source of error in the velocity estimates is the correction for the surface drift. They can lead to as much as a 10 percent uncertainty in some of the cross-wake distance scales on the cross-wake surface tension, film pressure and elasticity plots as well as the surfactant wake width estimates.

3.6. Summary of the STEMS Data Base Archive

Table 6 summarizes the STEMS data base from the Field Experiment. All of the processed runs are listed as well as the number of wake crossings completed during that run. Good data were collected during a total of fifteen test runs. These runs covered four different ship types, an FF, FFG, DDG, and TAO. Supporting information for each of these runs has been assembled into wake crossing data tables. Tables 7 and 8 list the information corresponding to Runs 1 and 3, and 2 and 4, respectively, on the 28th of January. A very short summary of the data included in the data notebooks that accompany this report is presented here. The data base for each of the runs in the data notebook includes:

1. Wake crossing data table.
2. Ln-Ln plot of surfactant wake width vs. distance aft of the ship.
3. Surface tension and film pressure vs. area graphs for the water samples collected during the test.
3. Cross-wake surface tension vs. time plots of the STEMS data.
5. Cross-wake surface tension, film pressure and elasticity vs. cross-wake distance plots of the STEMS data.
6. PMTC tracking plots of STEMS location during the run.
7. Tabulated listings of all the data files used to generate the graphs contained in the notebooks.

A more detailed and complete listing and description of the files and data plots is contained in Appendix

4.0 SURFACE WAKE MEASUREMENT RESULTS

4.1. *Surface Tension and Film Pressure Measurements*

Table 6. Summary of NRL STEMS cross-wake surface tension data

Navy Ship	Date of Run	Run Number	Ship Speed	Number of Wake Crossings Completed During The Run
USS Duncan, FFG-10	1/27/89	Run 2	12.9 m/s (25 kts)	3 Crossings
USS Duncan, FFG-10	1/27/89	Run 3	9.3 m/s (18 kts)	4 Crossings
USS Chandler, DDG-996	1/28/89	Run 1	6.2 m/s (12 kts)	4 Crossings
USS Chandler, DDG-996	1/28/89	Run 2	12.9 m/s (25 kts)	3 Crossings
USS Chandler, DDG-996	1/28/89	Run 3	9.3 m/s (18 kts)	4 Crossings
USS Chandler, DDG-996	1/28/89	Run 4	12.9 m/s (25 kts)	3 Crossings
USS Kawishiwi, T-AO 146	1/29/89	Run 1	6.2 m/s (12 kts)	4 Crossings
USS Kawishiwi, T-AO 146	1/29/89	Run 2	9.3 m/s (18 kts)	3 Crossings
USS Francis Hammond, FF-1067	1/31/89	Run 1	6.2 m/s (12 kts)	4 Crossings
USS Francis Hammond, FF-1067	1/31/89	Run 2	12.9 m/s (25 kts)	3 Crossings
USS Francis Hammond, FF-1067	1/31/89	Run 3	9.3 m/s (18 kts)	3 Crossings
USS Francis Hammond, FF-1067	1/31/89	Run 4	10.6 m/s (20.5 kts)	3 Crossings
USS Francis Hammond, FF-1067	2/1/89	Run 1	6.2 m/s (12 kts)	3 Crossings
USS Francis Hammond, FF-1067	2/1/89	Run 2	12.9 m/s (25 kts)	3 Crossings
USS Francis Hammond, FF-1067	2/1/89	Run 3	9.3 m/s (18 kts)	3 Crossings

Table 7. Wake crossing data table, Runs 1and 3

Date, Run/Leg, Ship	Ship Speed (m/s)	Time of Ship Passage	STEMS Wake Crossing Direction	Approximate Time to Wake Centerline (sec)	Approximate Distance Aft of the Ship m (ship lengths)	Estimated Wake Drift Velocity and Direction (m/s)	Time STEMS Entered the Wake	Time STEMS Exited the Wake	Total Wake Width m (Ship Beams)	Wind Speed m/s	Wind Direction N ↑ +θ	Time of Wind Measurement	Platform Reporting the Wind Measurement
Jan. 28, Run 1/Leg 1, DDG	6.2 m/s	8:42:12	N ↑ 0°	8:46: 05 (233)	1440.m (8.9 L)	↓ S .070 m/s	8:45: 20	8:46: 55	82 m (4.9 B)	.3 ± . 2 6.18	106° ± 106° 330°	8:42 8:30	McGaw Ship
Jan. 28, Run 1/Leg 2, DDG	6.2 m/s	8:42:12	↓ S 180°	8:53: 30 (678)	4190 m (26.0 L)	↓ S .030 m/s	8:52: 20	8:54: 45	106 m (6.3 B)	0.0 ± 0.0	50° ± 86°	8:52	McGaw
Jan. 28, Run 1/Leg 3, DDG	6.2 m/s	8:42:12	N ↑ 0°	9:00: 50 (1118)	6909 m (42.9 L)	↓ S .050 m/s	8:59:05	9:02:15	115 m (6.9 B)	.05 ± .05 5.67	118° ± 141° 20°	9:02 9:00	McGaw Ship
Jan. 28, Run 1/Leg 4, DDG	6.2 m/s	8:42:12	↓ S 180°	9:11: 20 (1748)	10803 m (67.0 L)	↓ S .050 m/s	9:09:35	9:13: 00	126 m (7.5 B)	.05 ± .05	34° ± 82°	9:12	McGaw
Jan. 28, Run 3/Leg 1, DDG	9.3 m/s	10:14:15	N ↑ 0°	10:19:40 (335)	3106 m (18.1 L)	↓ S .050 m/s	10:18:30	10:21:15	118 m (7.0 B)	0.57 ± 0.72 2.5 2.57	54° ± 61° 30° 38°	10:12 10:16 - 10:21 10:00	APL TRW Ship
Jan. 28, Run 3/Leg 2, DDG	9.3 m/s	10:14:15	↓ S 180°	10:26:30 (735)	6814 m (39.7 L)	↓ S .13 m/s	10:25:15	10:28:15	131 m (7.8 B)	0.52 ± 0.41 3.0 - 4.0 2.57	108° ± 40° 30° 48°	10:22 10:24 - 10:31 10:30	APL TRW Ship
Jan. 28, Run 3/Leg 3, DDG	9.3 m/s	10:14:15	N ↑ 0°	10:38:55 (1480)	13764 m (85.4 L)	↓ S .167 m/s	10:37:25	10:40:40	140 m (8.4 B)	0.41 ± 1.03 4.5 2.57	150° ± 34° 30° 48°	10:32 10:36 - 10:40 10:30	APL TRW Ship
Jan. 28, Run 3/Leg 4, DDG	9.3 m/s	10:14:15	↓ S 180°	10:48:20 (2045)	18957 m (110.5 L)	↓ S .09 m/s	10:46:00	10:50:50	147 m (8.8 B)	4.0 2.57	30° 67°	10:46 - 10:50 11:00	TRW Ship

Table 8. Wake crossing data table, Runs 2 and 4

Date, Run/Leg, Ship	Ship Speed (m/s)	Time of Ship Passage	STEMS Wake Crossing Direction	Approximate Time to Wake Centerline (sec)	Approximate Distance Aft of the Ship m (ship lengths)	Estimated Wake Drift Velocity and Direction (m/s)	Time STEMS Entered the Wake	Time STEMS Exited the Wake	Total Wake Width m (Ship Beams)	Wind Speed m/s	Wind Direction N +θ	Time of Wind Measurement	Platform Reporting the Wind Measurement
Jan. 28, Run 2/Leg 1 DDG	12.9 m/s	9:27:13	N 0°	9:33: 15 (362)	4663 m (28.9L)	S 0.0 m/s	9:31: 53	9:35:00	140 m (8.4 B)	$.62 \pm .62$ 4.12	$118^\circ \pm 92^\circ$ 38°	9:32 8:30	McGaw Ship
Jan. 28, Run 2/Leg 2 DDG	12.9 m/s	9:27:13	S 180°	9:42: 00 (887)	11425 m (70.9L)	S .15 m/s	9:39: 35	9:44:15	155 m (9.3 B)	$2.52 \pm .77$	$74^\circ \pm 14^\circ$	9:42	McGaw
Jan. 28, Run 2/Leg 3 DDG	12.9 m/s	9:27:13	N 0°	9:51: 50 (1477)	19024 m (118.0L)	S .08 m/s	9:49: 25	9:54: 30	170 m (10.1 B)	3.91 ± 1.08 6.18	$72^\circ \pm 28^\circ$ 38°	9:52 10:00	McGaw Ship
Jan. 28, Run 4/Leg 1 DDG	12.9 m/s	11:05:15	N 0°	11:10:05 (290)	3735 m (21.8 L)	S .14 m/s	11:08:35	11:11:45	125 m (7.5 B)	3.5 2.57	90° 67°	11:06 - 11:13 11:00	TRW Ship
Jan. 28, Run 4/Leg 2 DDG	12.9 m/s	11:05:15	S 180°	11:20:45 (930)	11978 m (69.8 L)	S .075 m/s	11:18:00	11:23:35	147.7 m (8.8 B)	2.25 - 3.5 2.57	90° 35°	11:16 - 11:26 11:30	TRW Ship
Jan. 28, Run 4/Leg 3 DDG	12.9 m/s	11:05:15	N 0°	11:32:50 (1655)	21316 m (124.2 L)	S .09 m/s	11:30:45	11:35:25	166 m (9.9 B)	3.0 2.57	90° 35°	11:28 - 11:33 11:30	TRW Ship

The STEMS data processing consists of playing back the video tapes several times and recording the spreading behavior of each oil. In this manner the dividing line between spreading and nonspreading of the oils is determined as a function of time on the video. Readings are made each second. The time series of surface tension is then input to a computer together with the film pressure-area and elasticity data from the Langmuir trough. Also, wave damping coefficients (as a function of elasticity for a given surface wavelength) can be calculated. Finally cross-wake profiles or two-dimensional maps of surface tension, film pressure, elasticity, and wave damping can be generated for a given surface wavelength.

We present here in Figures 12 through 15 and 17 through 20 the cross-wake surface tension profiles for eight runs during the 1989 Field Experiment. The first four runs were made on January 28 by a Navy destroyer (DDG 996) at speeds of 12 (6.2 m/s), 25 (12.9 m/s), 18 (9.3 m/s), and 25 (12.9 m/s) knots. The second four runs were made by a Navy frigate at speeds of 12 (6.2 m/s), 25 (12.9 m/s), 18 (9.3 m/s), and 20.5 (10.55 m/s) knots on January 31. The winds were 5 - 12 knots from the northeast on January 28 and 0 - 4 knots from the southeast on January 31. The sea surface was dominated by small wind waves, and there were some small, visible ambient surface slicks on January 28, whereas the sea surface was almost glassy calm and covered by large, visible ambient surface slicks on January 31.

We include here for each of the wake crossings the measured surface tension profiles across the wake. The corresponding film pressure profiles can be calculated using equation (1) with α taken as the surface tension measured in the clean water well outside of the wake. The film pressure directly relates our field measurements to the laboratory-determined elasticity. The approximate time to the wake centerline is the amount of time that elapsed after the target ship passed before STEMS reached the wake centerline during each of the data crossings. Multiplying this time value by the target ship's speed gives the corresponding distance aft at which each of the crossings were made. All crossings are plotted so that the water south of the wake (0.0 m) is at the left of the figure. The wake edges are defined as the location of the edge of the outermost foam bands in the video record made by the STEMS as it crossed the wake and/or the region corresponding directly to the sudden decrease (or increase) in surface tension measured by the STEMS as it entered (or exited) these outermost surfactant bands aligned with the turbulent wake. The wake widths were determined by multiplying the speed of the towed STEMS platform by the total time it took the

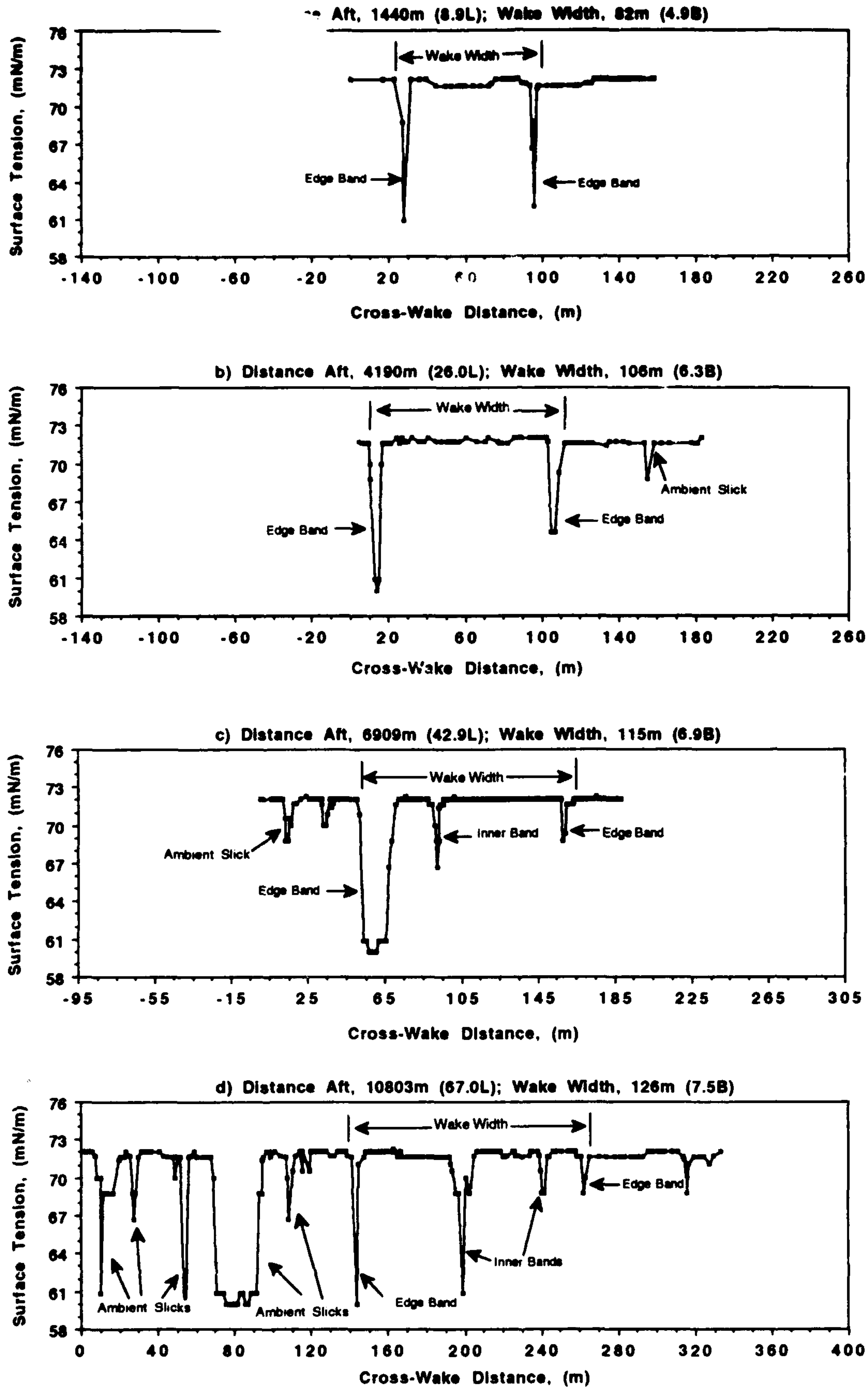


Figure 12. Measured cross-wake surface tension distribution (*a*) 1440, (*b*) 4190, (*c*) 6909, and (*d*) 10,803 m aft of the Navy destroyer. The ship speed was 12 knots, or 6.2 m/s ($Fr = 0.156$).

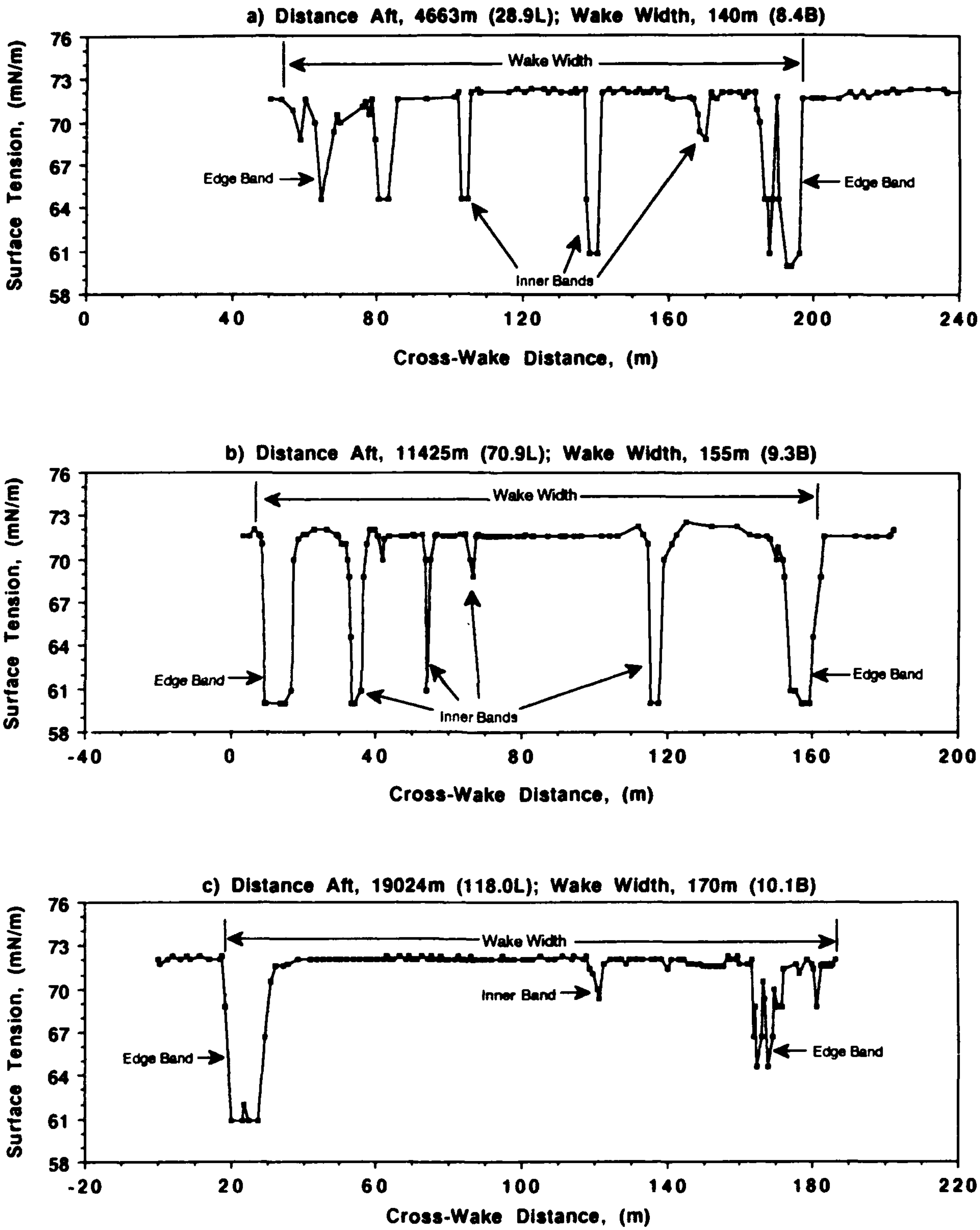


Figure 13. Measured cross-wake surface tension distribution (*a*) 4663, (*b*) 11,425, and (*c*) 19,024 m aft of the Navy destroyer. The ship speed was 25 knots, or 12.9 m/s ($Fr = 0.324$).

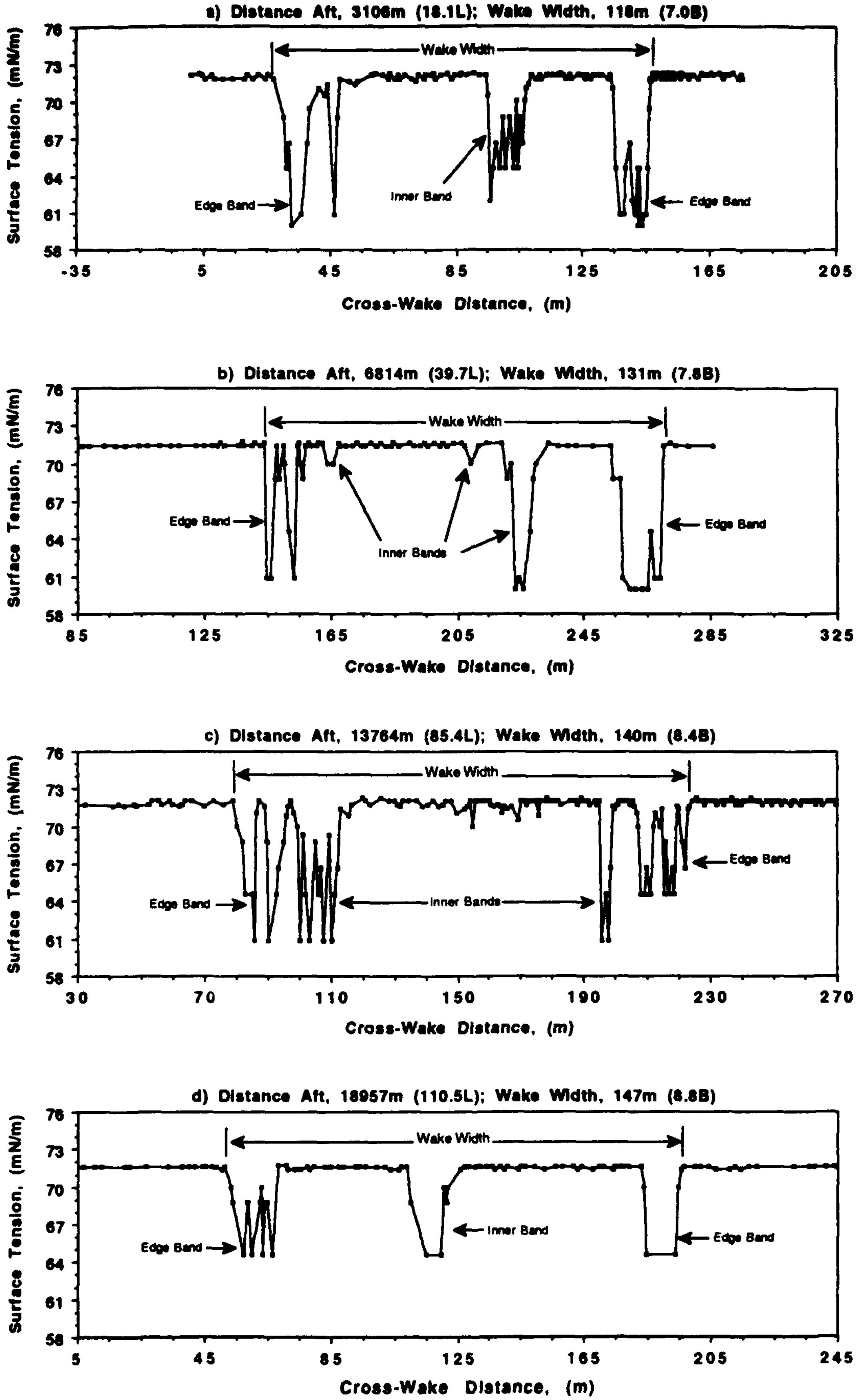


Figure 14. Measured cross-wake surface tension distribution (*a*) 3106, (*b*) 6814, (*c*) 13,764, and (*d*) 18,957 m aft of the Navy destroyer. The ship speed was 18 knots, or 9.3 m/s ($Fr = 0.233$).

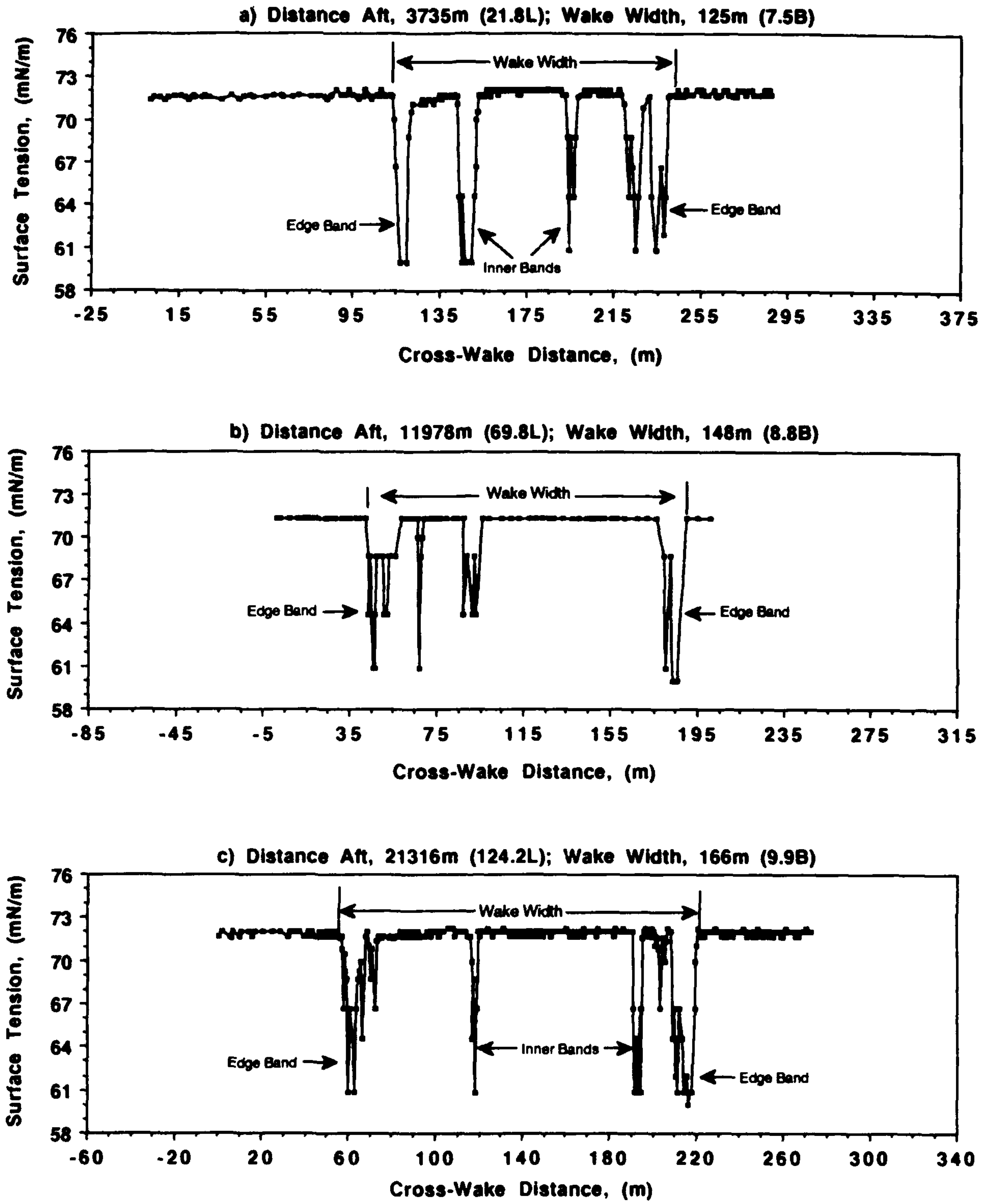


Figure 15. Measured cross-wake surface tension distribution (*a*) 3735, (*b*) 11,978, and (*c*) 21,316 m aft of the Navy destroyer. The ship speed was 25 knots, or 12.9 m/s ($Fr = 0.324$).

STEMS to cross the wake. Wake widths determined by this method are only as accurate as the Pacific Missile Test Center (PMTC) tracking data used to determine the speed of the STEMS during the measurements. Surface currents that sometimes were found to advect the wake in a northerly or southerly direction were accounted for in the analysis.

We were not able to measure the minimum surface tension value in certain regions of the crossings. For the crossings shown in Figures 12 through 15, we have assigned an arbitrary value of 60.0 mN/m to those regions where oil 21 did not spread and in Figures 17 through 20, we have assigned a value of 50 mN/m to those regions where oil 22 did not spread. These values are only slightly less than the measured values of 60.82 and 53.44 mN/m associated with oils 21 and 22, which did not spread.

Surface tension measurements were obtained along four wake crossings centered at 1440 m, 4190 m, 6909 m, and 10,803 meters aft of the destroyer during the 12-knot run on January 28. These cross-wake surface tension distributions are shown in Figure 12. Regions of decreased surface tension relative to the ambient value are caused by increased film pressure of a compacted surfactant in those regions. Each of the first two crossings has two edge bands of compacted film that outline the turbulent, centerline wake. The third and fourth crossings contain one or more additional bands between the edge bands.

Three crossings, centered at 4663 m, 11,425 m, and 19,024 m, were made by the STEMS during the first 25-knot run by the destroyer, and the results are shown in Figure 13. Each of the three crossings has two distinct edge bands of compacted surface active material that correspond directly to the outer foam bands generated in the region of the ship's breaking bow wave. In addition, there are several internal bands present in the centerline wake as well.

The four cross-wake surface tension profiles (Figure 14) obtained during the 18-knot destroyer run show strong edge bands, several inner bands, and a persistent band of lower surface tension near the center of the wake even as far downstream from the target ship as 19 km or 2045 s late.

Surface tension measurements were obtained during the second 25-knot run by the destroyer along three wake crossings centered at 3735 m, 11,978 m, and 21,316 m aft of the ship. The cross-wake surface tension distributions are shown in Figure 15. Each of the three crossings has two edge bands of compacted film as well as one or more additional bands between the edge bands.

As was the case in the first 25-knot run, it is not clear whether these inner bands persist, but rather move around, or appear and disappear. There is also reasonable agreement between the widths of the wake at comparable downstream locations in both 25-knot runs.

One common feature in all of these runs on January 28 was that the two outermost bands were visible to the eye as slicks, whereas this was not generally true for the inner bands. Since the surface is already smooth in the centerline region of the turbulent wake, the visibility of these inner bands is limited. In addition, the surfactant films do not allow the wind waves to regrow in these regions and limit the regrowth throughout the entire centerline wake region. The outer bands are visible because of the contrast between the ambient surface where small waves are present and the smooth surface where the small waves have been damped by the compacted surfactant material. From these results it is clear that the origin of these outer bands of foam and compacted surface-active material is directly related to the complex hydrodynamic processes taking place in the ship wake. There is a strong convergence region at the edge of the wake, and so it is not surprising that material accumulates there. Although the origin of the inner bands is not quite so clear, there are also several convergence regions in the centerline wake that can be responsible for accumulating and compacting the surface-active materials that have been scavenged to the surface by the rising bubbles into film bands.

There are several other significant features in the runs on January 28. The surface tension of the clean water in the core of the wake generally has the same value as the clean ambient water away from the wake. The width of the wake (W), defined previously as the distance between the outer surfactant edge bands, increases with time (and distance astern, X) in all the runs. Figure 16 compares the wake widths, normalized by the ship's beam B, (the stern of the ship is at $X = 0.0$) as a function of downstream distance (X/L, where L is the ship length) for each of the different ship speeds. One sees that the wake is significantly narrower at the lower speeds and increases in width as the ship speed increases. This feature is again the result of the hydrodynamic processes in the ship wake. Video records of the destroyer wake at the three speeds also exhibit these features. The slight variation between the two 25-knot runs is most likely due to the differences in wind speed and direction between the two runs. Included in the figure are straight lines with a slope of one-sixth, one-fifth and one-fourth to give an estimate of the rate at which the surfactant wake spreads with downstream distance.

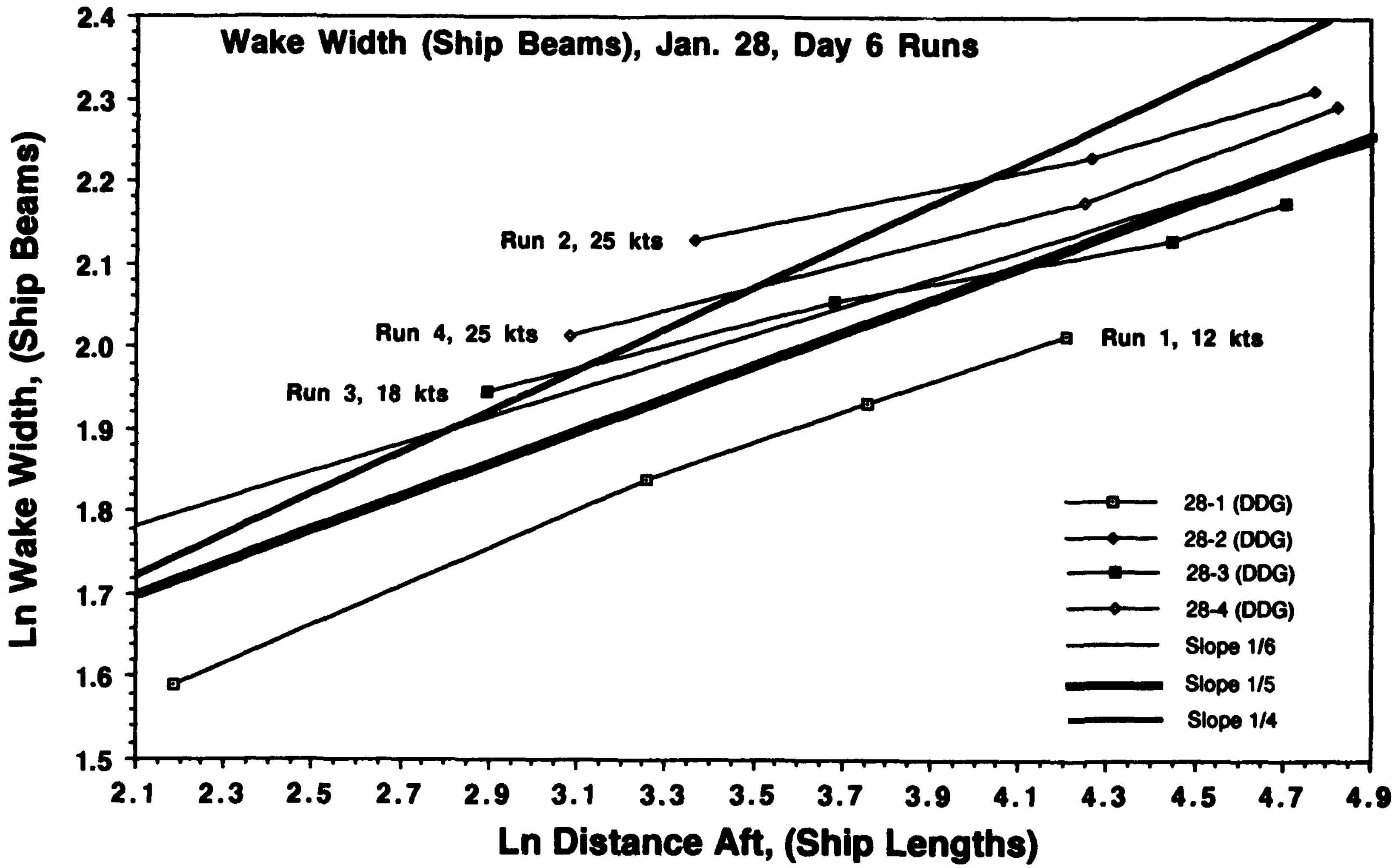


Figure 16. Measured surfactant wake width versus downstream distance for the four Navy destroyer runs.

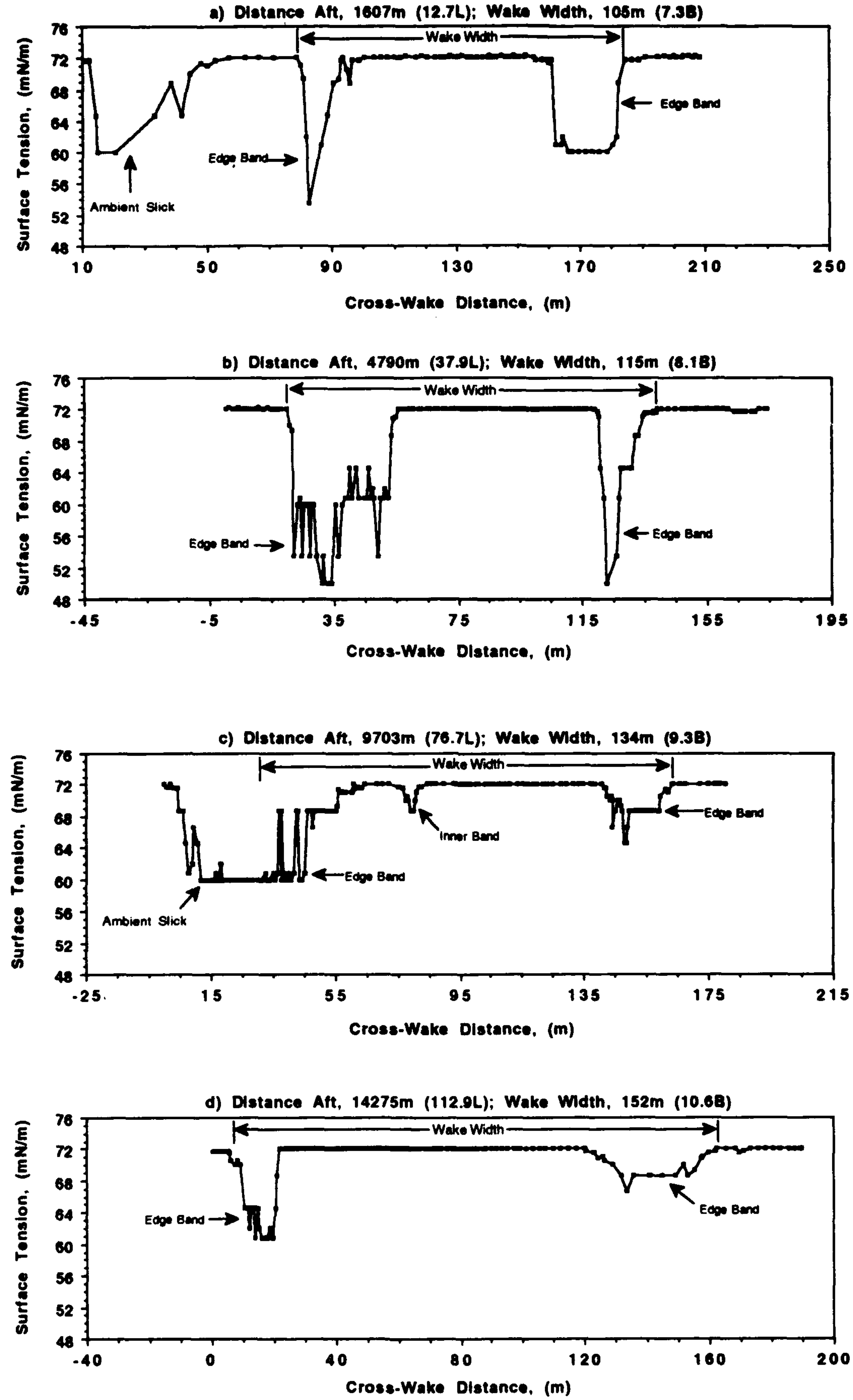


Figure 17. Measured cross-wake surface tension distribution (*a*) 1607, (*b*) 4790, (*c*) 9703, and (*d*) 14,275 m aft of the Navy frigate. The ship speed was 12 knots, or 6.2 m/s ($Fr = 0.176$).

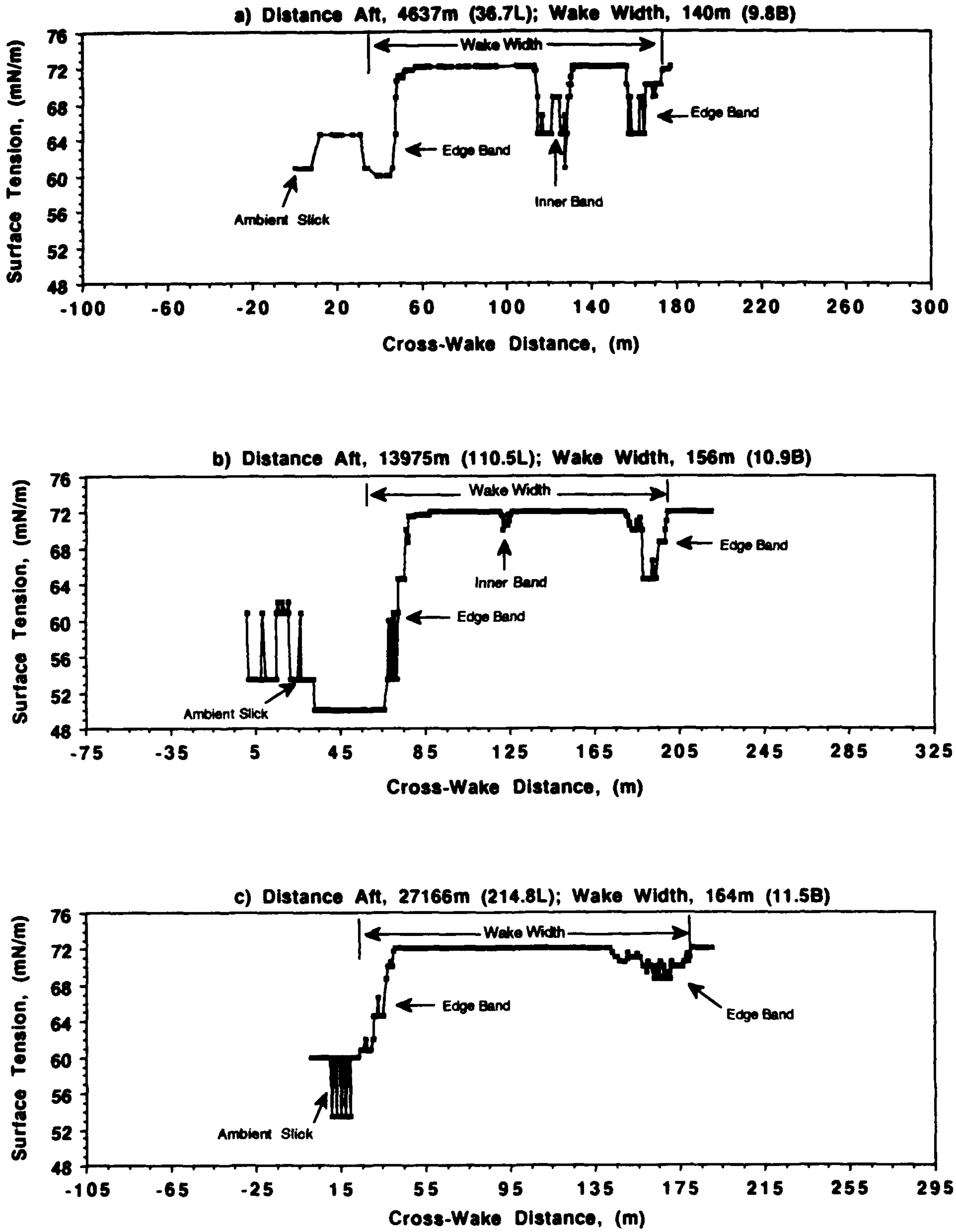


Figure 18. Measured cross-wake surface tension distribution (*a*) 4637, (*b*) 13,975, and (*c*) 27,166 m aft of the Navy frigate. The ship speed was 25 knots, or 12.9 m/s ($Fr = 0.366$).

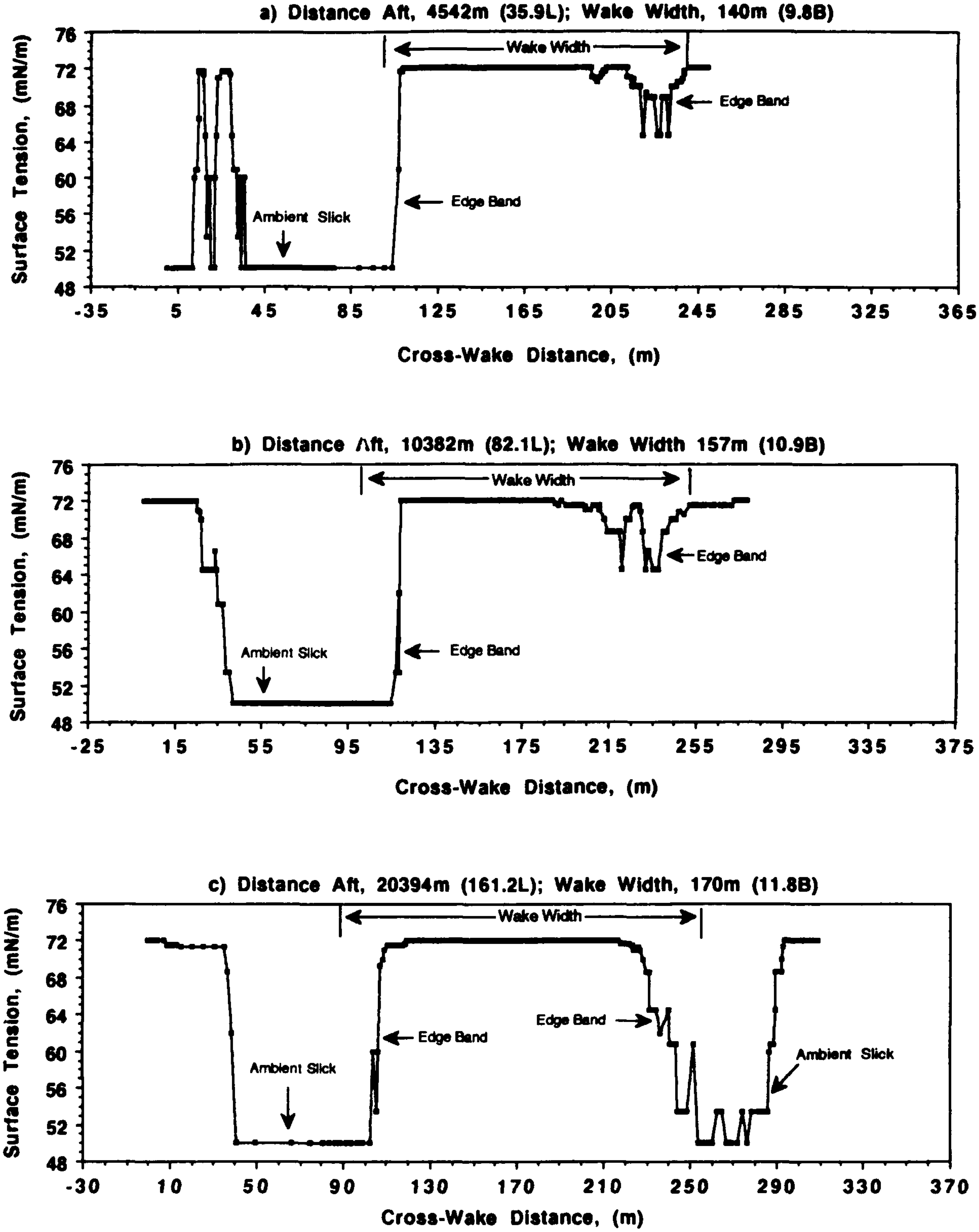


Figure 19. Measured cross-wake surface tension distribution (*a*) 4542, (*b*) 10,382, and (*c*) 20,934 m aft of the Navy frigate. The ship speed was 18 knots, or 9.3 m/s ($Fr = 0.263$).

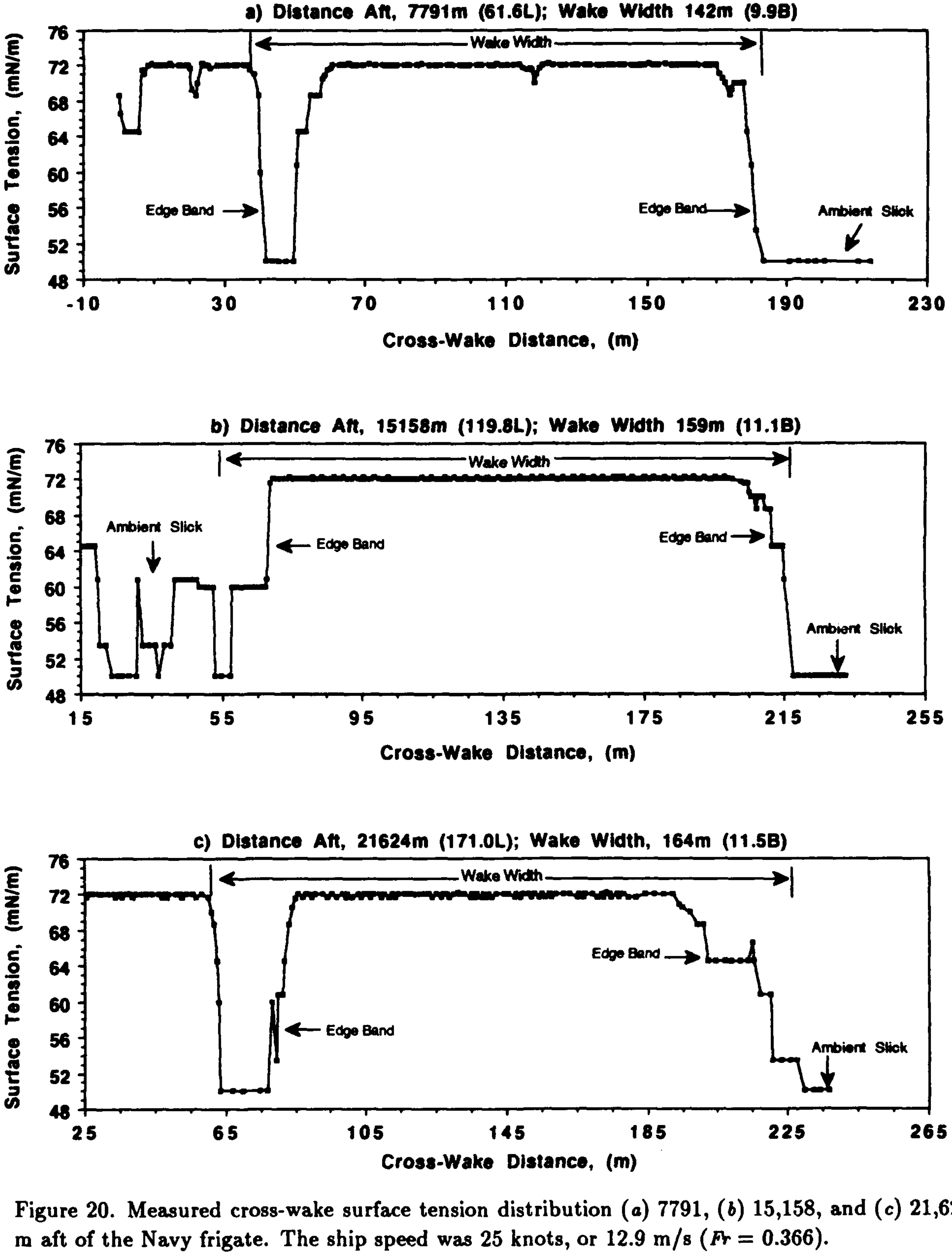


Figure 20. Measured cross-wake surface tension distribution (a) 7791, (b) 15,158, and (c) 21,624 m aft of the Navy frigate. The ship speed was 25 knots, or 12.9 m/s ($Fr = 0.366$).

A multiband (L,C,X band) SAR image of the destroyer wake (second 25-knot run) was obtained by an aircraft flying parallel to the wake during the same time that the surface tension measurements were being made by STEMS as it was towed across the wake by the *R/V Garnet Banks*. The L-band SAR image recorded during the test run is shown here in Figure 2. Thus the predominant Bragg scattering waves to which the SAR is most sensitive propagate directly across the wake. In four recent papers, *Peltzer et al.* [1990, 1992] and *Milgram et al.* [1993*a,b*], the multiband SAR backscatter intensity data has been compared with the corresponding surface tension data (Figure 15) from the 3735-m wake cut. The L-band SAR data show that the L-band waves have not recovered to ambient levels and are attenuated across the entire wake. The L-band data also show that several of the variations in intensity across the wake can be visually matched up with the regions of reduced surface tension in the compacted surface film bands. The C-band SAR data show backscatter intensity in the wake to be nearly at ambient levels except in isolated regions whose locations are in reasonable correspondence with the zones of compressed surface films. The reductions in image intensity in these regions are about 6 dB at L-band and 5 dB at C-band. Both of these studies concluded that there is a definite correlation between the regions of the largest backscatter intensity reduction in the SAR data and the regions of lowest surface tension in the cross-wake surface tension plot at 3735 m. The X-band signal to noise ratio was near unity for this run, so that any direct comparison with the data was subject to some error, and was not included in the analysis.

The STEMS made four wake crossings during the 12-knot run by the frigate on January 31. The cross-wake surface tension profiles at 1607 m, 4790 m, 9703 m, and 14,276 m downstream are shown in Figure 17. Note that oil 22 was not working during the third and fourth crossings. The southern edge of the wake has combined with a small ambient slick during the second and fourth crossings. The edge of the wake at these locations was determined by the location of the visible foam band in the video and comments in the data logs. During the first and third crossings the southern edge band is distinct. The compacted film band at the northern edge of the wake is highly persistent and exhibits a sharp reduction in the minimum surface tension value as the wake ages. This implies that the concentration of the surface-active material in the film band is decreasing as the wake ages. The width of the surfactant wake increases with time.

Three cross-wake surface tension profiles centered at 4637 m, 13,975 m, and 27,166 m downstream are shown in Figure 18 for the 25-knot run by the frigate on January 31. Oil 22 was not working on the first crossing. The southern edge of the wake is again dominated by a large ambient slick. The wake edges were again determined by the location of the visible foam bands and the data logs. The width of the surfactant film band at the northern edge of the wake increases and the maximum film pressure in the band decreases as the wake ages and the band spreads. A separate inner band that disappears quickly is also evident in the data. The width of the wake increases with time and, as expected the wake is significantly wider than the frigate's wake at 12 knots.

The STEMS crossed the wake at the three downstream locations of 4542 m, 10,382 m, and 20,934 m during the 18-knot run by the frigate on January 31. Figure 19 shows the surface tension profiles at these locations. Oil 22 was working during all three crossings. The southern edge of the wake is dominated by a large ambient slick throughout the entire run, and the northern edge has also combined with an ambient slick during the third crossing. The ambient slick has a very high film pressure, indicating that there is a large concentration of surface-active material present in the slick. The film pressure in the centerline region of the wake is zero, which means that the water surface is no longer covered by an ambient surface film in this region as it had been before the ship passed. The surface motions, bubbles and currents generated by the ship have removed the material from the center region and compacted it into bands at the edges of the wake.

The results from the 20.5 knot run by the frigate on January 31 are shown in Figure 20 Crossings were made at three downstream locations centered at 7791 m, 15,158 m, and 21,624 m. The northern edge of the wake is dominated by a large ambient slick during the entire run, and the edge band on that side is indistinguishable from the slick in our data. The southern edge has combined with an ambient slick during the second crossing as well. The wake edges in these instances were again determined by the location of the visible foam bands in the videos and the data logs. The southern edge band is very persistent. The true width of the wake during the third crossing is uncertain because the foam had nearly disappeared and the ambient slickiness made it hard to locate the true wake edge on either side. However, the data logs allowed us to get a reasonably accurate estimate of the location of the edges. The ship has again passed directly through an ambient surface slick, removed the surface film from the wake center region,

and concentrated the material at the edges of the wake. There is evidence of a very small internal film band in the wake centerline during the first crossing, similar to the one found in the first 25-knot run. The width and structure of the wake in the 20.5 and 25-knot runs by the frigate on January 31 are similar.

As was the case for the destroyer wakes, the width of the wake, defined previously as the distance between the outer surfactant edge bands, increases with time (and distance astern) in all the runs. Comparing the wake widths (the stern of the ship is at $X = 0.0$) versus downstream distance for each of the ship speeds in Figure 21, one sees that the wake is significantly narrower at the lower speeds and increases in width as the ship speed increases. The separation between the curves is not quite as evident for these results because one or both of the the wake edges were typically indistinguishable from the adjacent ambient slicks during the runs. This made it difficult to locate the true wake edges. Video records of the frigate wakes at the three speeds also exhibit these features. Straight lines with a slope of one-sixth and one-fifth are included in the figure to give an estimate of the rate at which the surfactant wake spreads with downstream distance.

In all of the wake crossings examined in this report, both edge bands (if they were not embedded in a natural slick) were visible to the eye and showed a pronounced depression in surface tension. They corresponded directly with the location of the outermost foam bands. Several interior bands appeared and were reasonably persistent. For the runs on January 28 the ambient water did not have any measurable accumulation of surfactant material, and the surface tension in the core of the wake has the same value as the ambient (away from the wake). For the runs on January 31 where the ship passed through large, ambient slicks, the surface motions, bubbles, and currents generated by the ship have removed the material from the center region and compacted it into bands at the edge of the wake. Similar overall behavior is evident in the additional test results which are included in the Appendix of this report. All of these results demonstrate that in addition to the ambient surface conditions, the complex hydrodynamics of the ship wake plays a major role in determining the characteristics of the surfactant wake.

The surfactant bands at the edges of the wake are highly persistent once they are formed. There are several factors that may contribute to the stability of these bands. Generally, a horizontal spreading toward areas of cleaner water will result from the accumulation of excess material in one area, such as in the film bands. In the sea, where low concentrations of material are believed

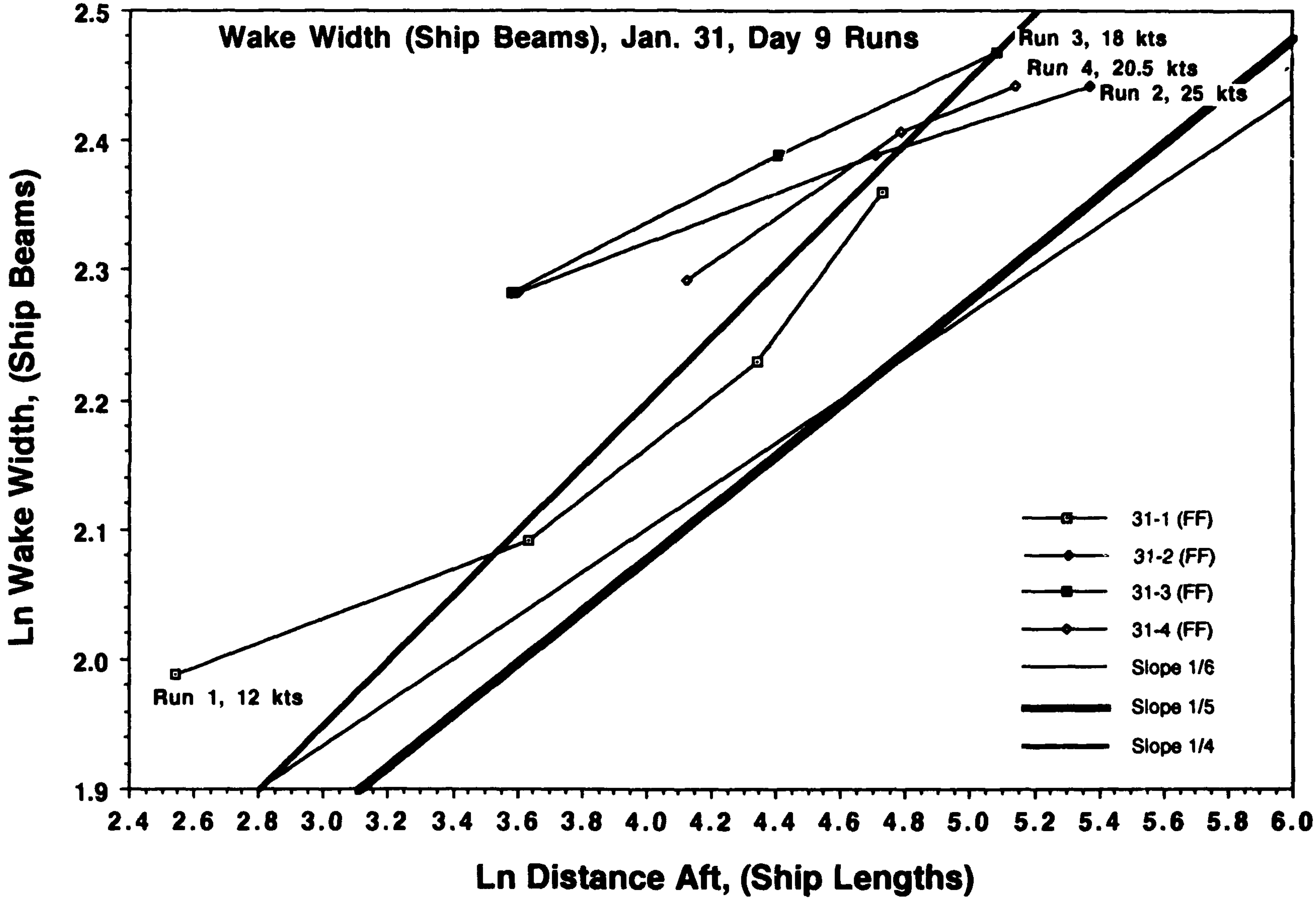


Figure 21. Measured surfactant wake width versus downstream distance for the four Navy frigate runs.

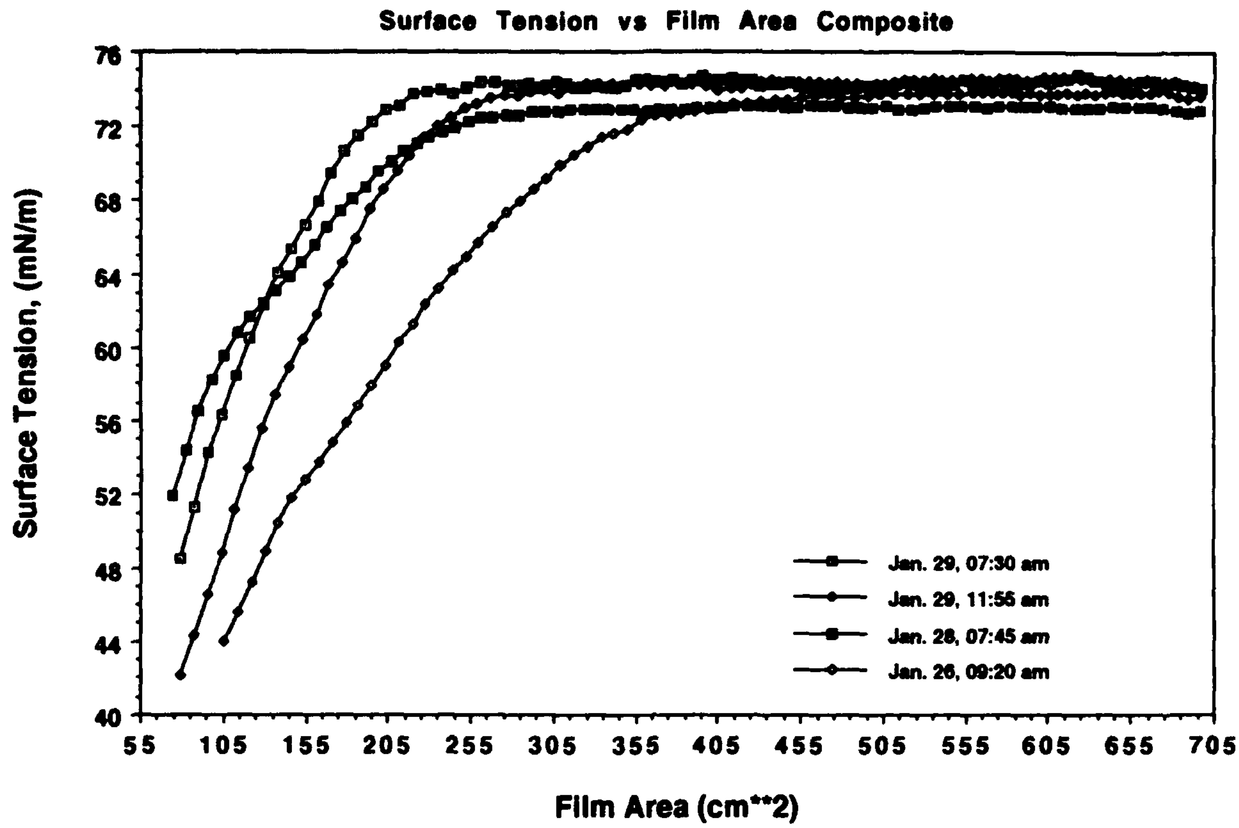
to always contaminate the surface, the spreading film will drive the widely separated ambient material into a surrounding film that opposes and slows the outward spreading of the film in the bands. Cohesive, electrostatic attractive forces within the surface film also oppose disintegration of the film. Once the film is formed, a considerable amount of energy is required to force the surface-active material back into solution. There is evidence to suggest that some displacement hulls shed a pair of persistent vortices which provide one means to transport the surface-active material away from the center of the wake toward the edges [*Peltzer et al.*, 1990; *Kaiser et al.*, 1988]. This persistent motion prevents the material in the surfactant band from spreading back into the center region of the wake. It also provides a constant outflow of new material into the film band that has been scavenged to the surface by the remaining bubbles in the wake. Most likely a combination of all of the above factors contributes to the stability of these outer edge bands.

4.2. *Surfactant Film Pressure-Area Dependence*

The film pressure-area curve for the surfactant material is needed to relate the film elasticity E_s to the measured surface tension τ_{meas}. Figure 22 shows the surface tension - film area curves and film pressure - Ln film area curves for the water samples collected on the 26th, 28th, and 29th of January. All of the samples were allowed to stand for 18 to 24 hours before the measurements were made. Except for small differences due to material concentration variations, all the curves exhibit similar characteristics. We will now focus on the subsurface water sample collected prior to the runs by the destroyer on January 28 for later film pressure versus area measurements at NRL as described earlier. The results of these measurements, plotted as the natural logarithm of the film pressure (in millinewtons per meter) versus the natural logarithm of the surface area (in centimeters squared), are shown in Figure 23. These data have been fitted with three straight line segments, so that for each portion of the fitted curve we have

$$\Pi = CA^n, \tag{4}$$

where n is the slope of the portion and C is a characteristic constant of that portion of the curve. Then, from equation (2), we find that



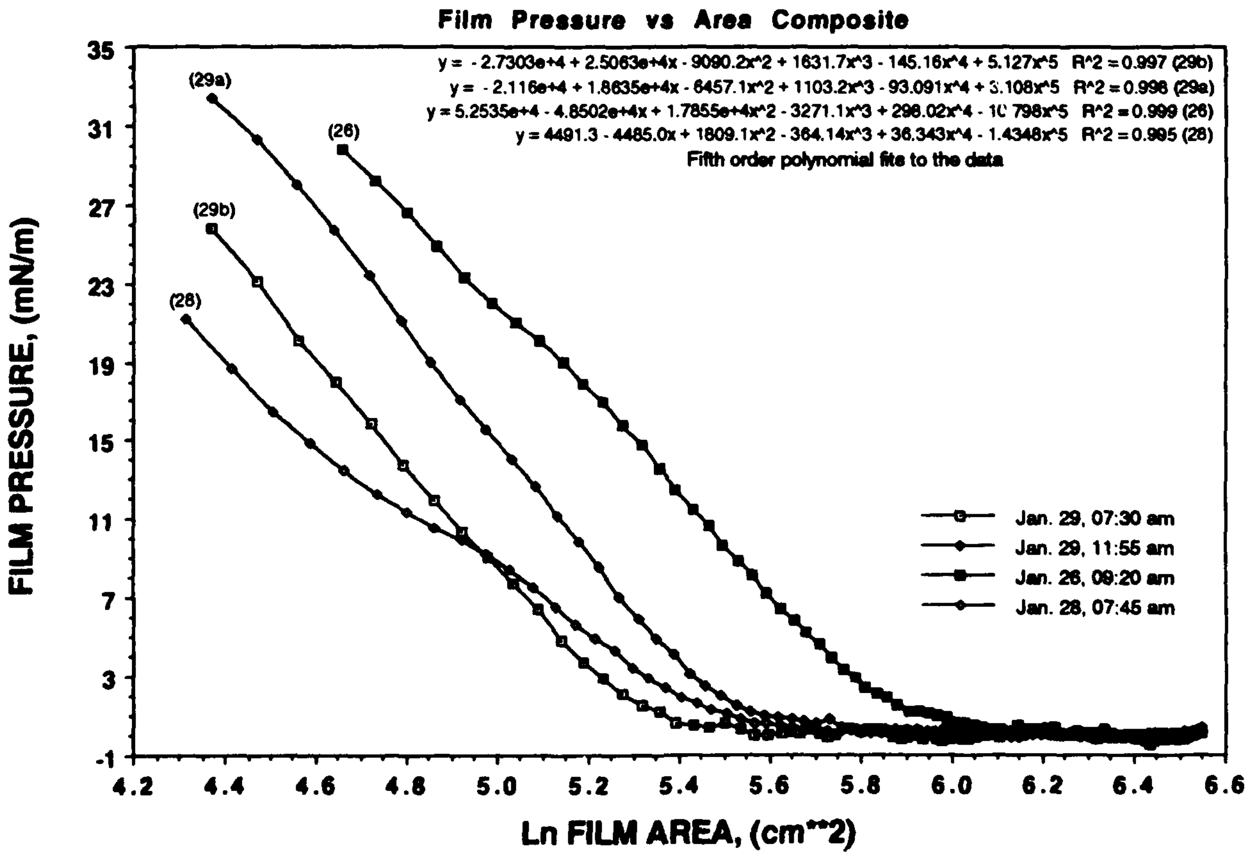


Figure 22. Measured (a) surface tension - film area, and (b) film pressure - Ln film area curves for the water samples collected on the 26th, 28th, and 29th of January, 1989.

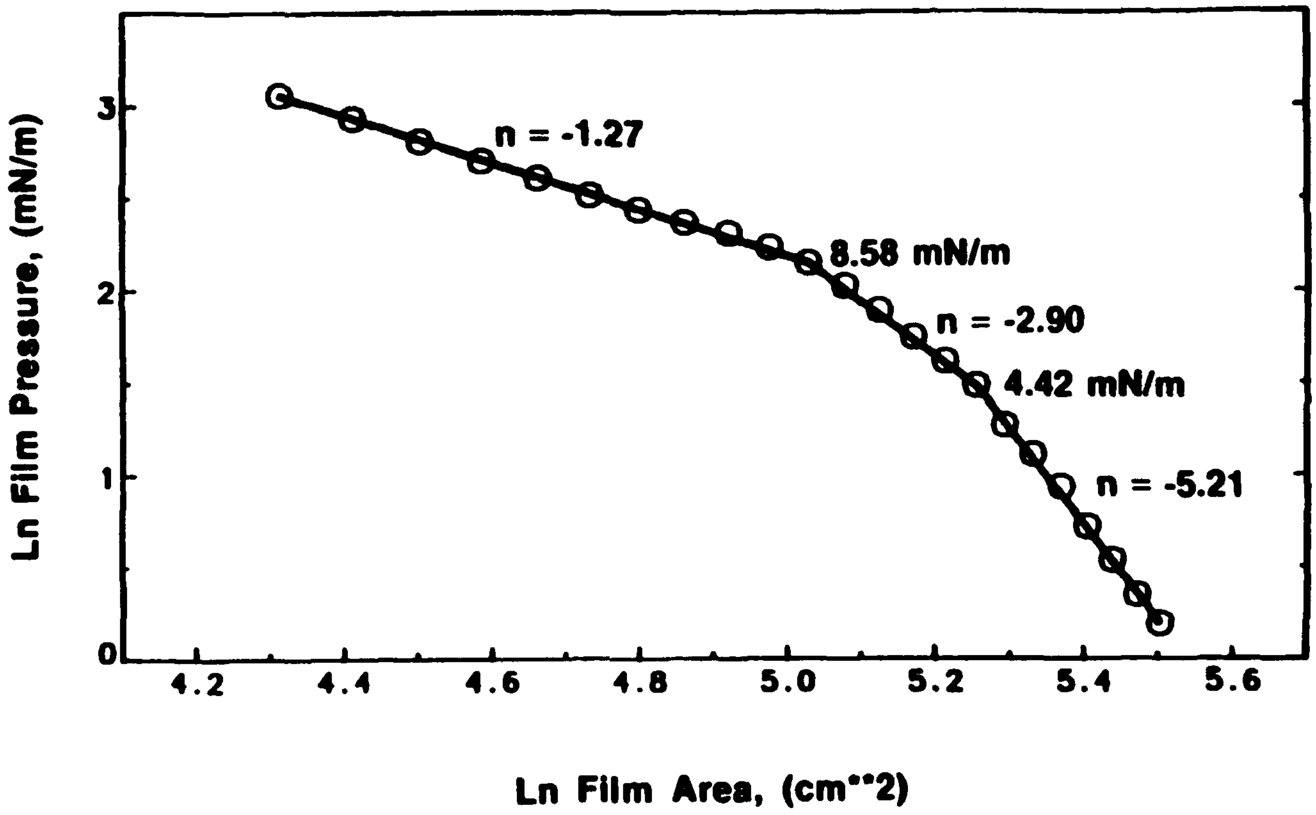


Figure 23. Measured surfactant film pressure-area curve for the water sample collected prior to the Navy destroyer test runs. The data have been best-fitted with three straight line segments.

$$E_s = -n\Pi, \tag{5}$$

or, specifically from the three-segment fit in Figure 23,

$$\begin{array}{lll} E_s = & 0.0 & \Pi \leq 0.20, \\ E_s = & 5.21\Pi & 0.20 < \Pi < 4.42, \\ E_s = & 2.90\Pi & 4.42 \leq \Pi \leq 8.58, \\ E_s = & 1.27\Pi & \Pi > 8.58. \end{array} \tag{6}$$

The dependence of the film elasticity E_s on the film pressure Π given by equation (6) is only an estimate of the elasticity based on the film pressure-area curve for a single water sample. There are several discontinuities in the relation that may or may not be real. If the molecules in the film go through abrupt phase changes as the film is being compressed, there could be several maxima in the data. These discontinuities most likely will disappear if the elasticity is calculated when the slope of the film pressure versus area curve is computed over narrow regions by a sliding boxcar technique. Here the points in the sliding box are fitted with a parabolic curve by the method of least squares and the first derivative of the equation for the parabola is used to determine the slope at the chosen value of area. A smoothing method such as this removes noise in the data and helps to avoid introducing errors when computing the slopes. *Barger and Klusty* [1992] have found a general relationship between the film elasticity and film pressure from the film pressure-area data for 68 seawater samples. That relationship, equation (7),

$$E_s = \frac{26.3\Pi}{\Pi + 2.4}, \tag{7}$$

shows that natural ocean films behave like two-dimensional, liquid like materials that reach a maximum in their modulus of elasticity of about 26 mN/m for values of film pressure below 10 mN/m. Film elasticity values given by equation (6), for film pressures below 10 mN/m, agree very well with the values that are given by the general relationship.

It is very difficult to determine the exact composition of the material in the surfactant film bands measured during the Field Experiment. There are literally hundreds of different materials present in these bands. Surface chemists [*Frew et al.*, 1990, *Barger and Means*, 1985] agree

that the major constituents of these film bands are relatively soluble, highly oxygenated and condensed, but poorly defined, polymeric materials of high molecular weight. However, it is not the composition of the material in the bands that is important, but rather the effects of physical properties of the material on the ambient wave field. *Barger and Klusty* [1992] have recently examined the physical behavior of films formed on 90 natural seawater samples from numerous locations which were collected by several techniques. After developing a method to normalize for variations in the quantity of film-forming material in the samples, they were able to show that there is a generalized relationship between film pressure and area that is qualitatively representative of the average film-forming surfactant material found in seawater. Given the relative similarity in the pressure-area curves of the water samples obtained during the Field Experiment with the generalized film pressure versus area isotherm, we feel confident that the physical properties of the films present during the Field Experiment are representative of surfactant films throughout the major oceans. To properly characterize and measure the physical properties of surfactants that are important for wave damping studies, controlled natural surfactant materials must be developed by extracting the material from natural seawater samples.

4.3. Cross-Wake Film Elasticity Measurements

Figures 24, 25, and 26 show the cross-wake surface tension, film pressure, and film elasticity distributions that correspond to Legs 1, 2, and 3 of Run 4 on January 28th. The elasticity has been computed using the relationships given by equations (6) and (7). The two elasticity curves are very similar in form, thus indicating that the elastic properties of the water surface during the runs on January 28th can be modeled appropriately by Barger's universal curve. All fifteen runs exhibit similar characteristics.

5.0 APPLICATIONS TO SHIP WAKE DETECTION AND CLASSIFICATION

All of the cross-wake surface tension profiles we have analyzed from data obtained during the ONR Field Experiment have exhibited a clearly defined banded surface tension structure which persists for tens of kilometers downstream of a surface ship. In lighter wind cases the bands were easily detected more than one hour late (equivalent to 35 to 40 km behind the target ship). The width of the surfactant wake grows slowly with time as can be seen here from the results plotted in

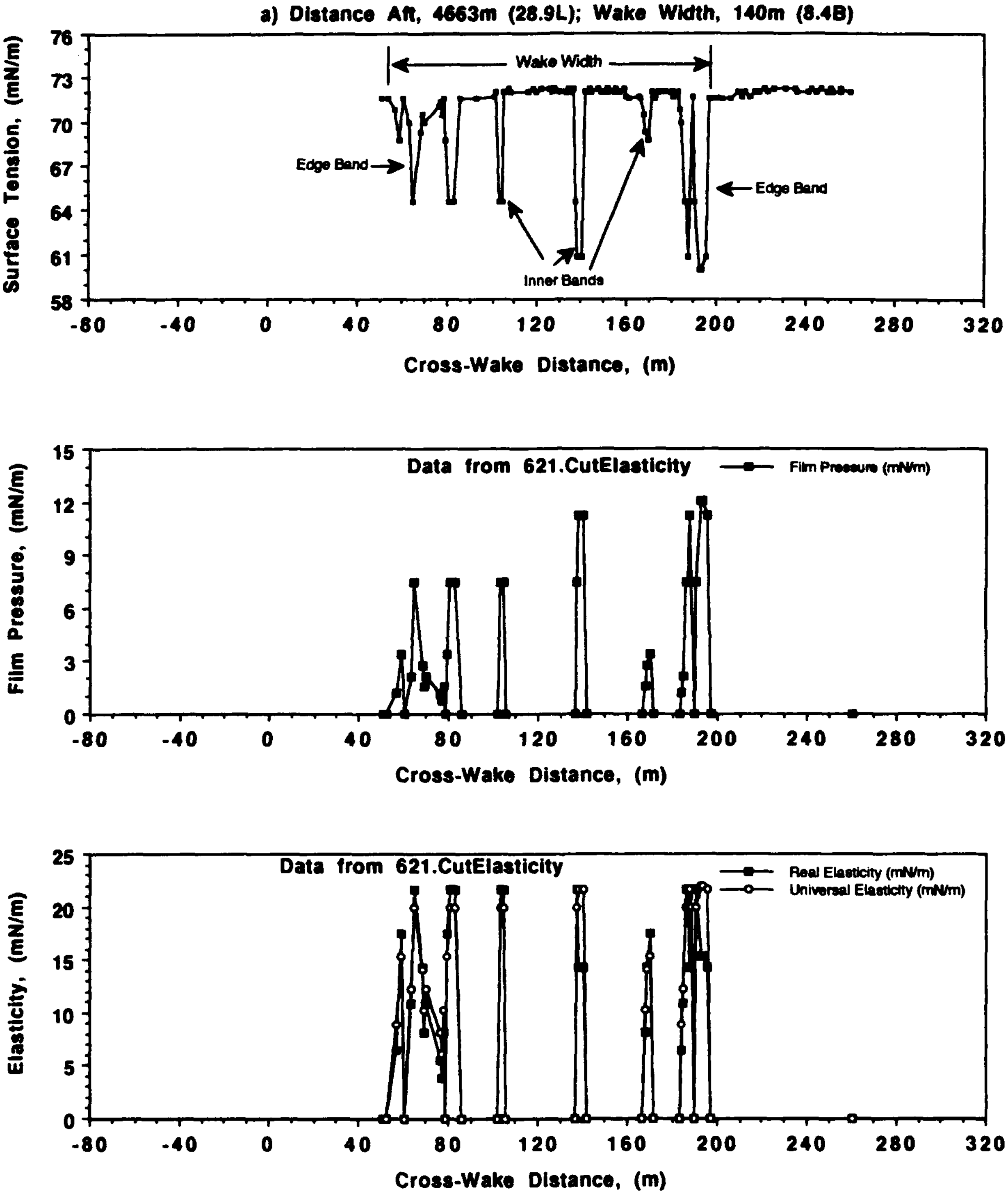


Figure 24. Cross-wake (a) surface tension, (b) film pressure, and (c) film elasticity distributions for Leg 1 of Run 4 on January 28, 1989.

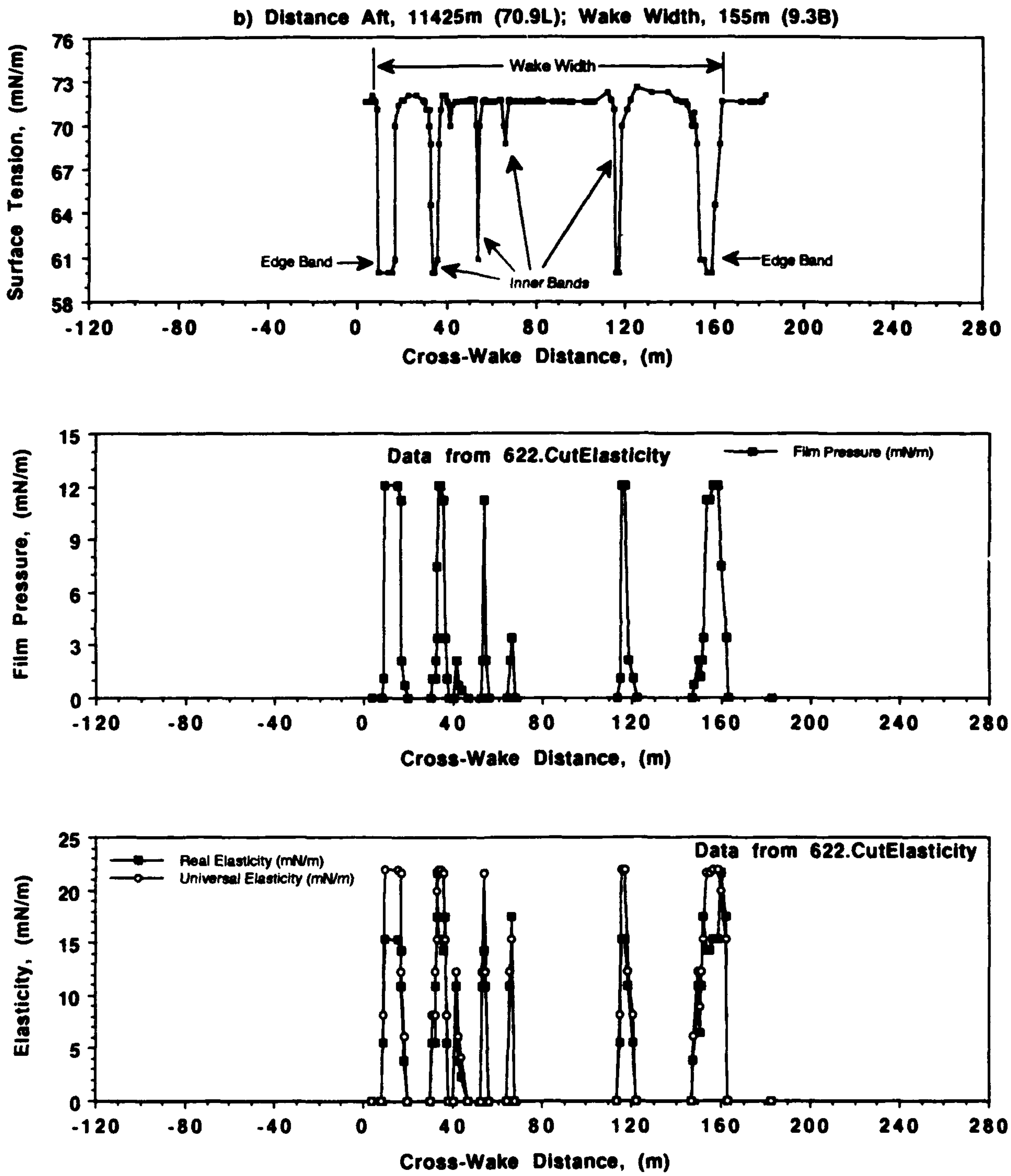


Figure 25. Cross-wake (a) surface tension, (b) film pressure, and (c) film elasticity distributions for Leg 2 of Run 4 on January 28, 1989.

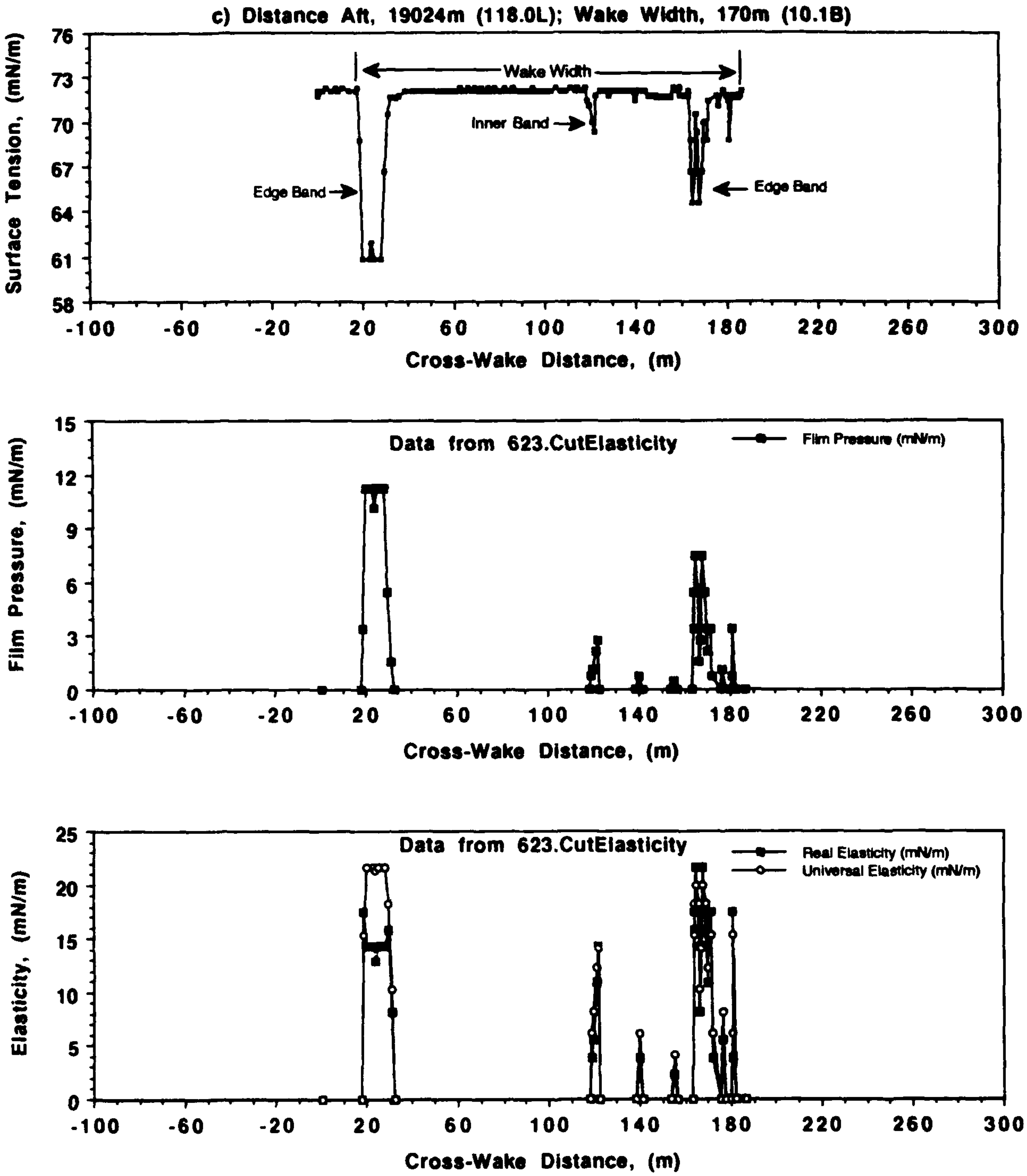


Figure 26. Cross-wake (a) surface tension, (b) film pressure, and (c) film elasticity distributions for Leg 3 of Run 4 on January 28, 1989.

Figures 16 and 21. The surfactant wake is significantly narrower at the lower speeds and increases in width as the ship speed increases. Figure 27 is a summary plot of all of the surfactant wake widths measured during the Field Test, and it further confirms the trends illustrated in Figures 16 and 21. This feature is the result of the complex morphology of the ship wake hydrodynamics, and video records of the destroyer and frigate wakes over the range of test speeds from 12 to 25 knots support this conclusion.

Previous to the ONR Field Experiment, in situ surface tension data had never been measured to the resolution in surface tension obtained or with such a fine spatial resolution. Combining these new measurements with the determination of the pressure-area curves has for the first time allowed us to infer film elasticity properties for ocean water and to realistically infer changes in the surface concentration of surface-active materials when they have been redistributed and compacted into bands by the ship's forward motion through the water surface. Surface-active films that have been concentrated at the edges of the centerline wake strongly influence the propagation of short gravity and capillary waves which interact with electromagnetic waves at both radar and visible wavelengths. These and other factors which contribute to the complexity of the surface wake SAR images are illustrated in the following examples.

Figure 28 shows two SAR images of the Navy battleship which participated in the 1989 experiment. The ship was travelling at 18 knots in the range direction relative to the passage of the airborne SAR. Both L-band (1.2 GHz, 25 cm wavelength) and C-band (5.3 GHz, 5.7 cm) images are shown for comparison purposes. The range of the radar incidence angles in the scene relative to the vertical direction is included in the right-hand scale in the figure. Several characteristic features of the image can be noted. The dark centerline wake is visible in both images, though the L-band feature is the more distinct of the two. Also, the bright return from the ship in the lower portion of the images is displaced from the centerline wake. This is a result of relative motion between the azimuth-travelling SAR and the range-travelling ship. The spatially variable bright regions in the images are caused by the enhanced backscatter return from these surface areas as compared to the darker portions of the images which are relatively smooth and free of short-wavelength scatterers.

The L-band SAR image of the Navy destroyer travelling in the azimuthal direction is shown in Figure 29. Again the right hand vertical scale gives the radar angle of incidence. The bright image

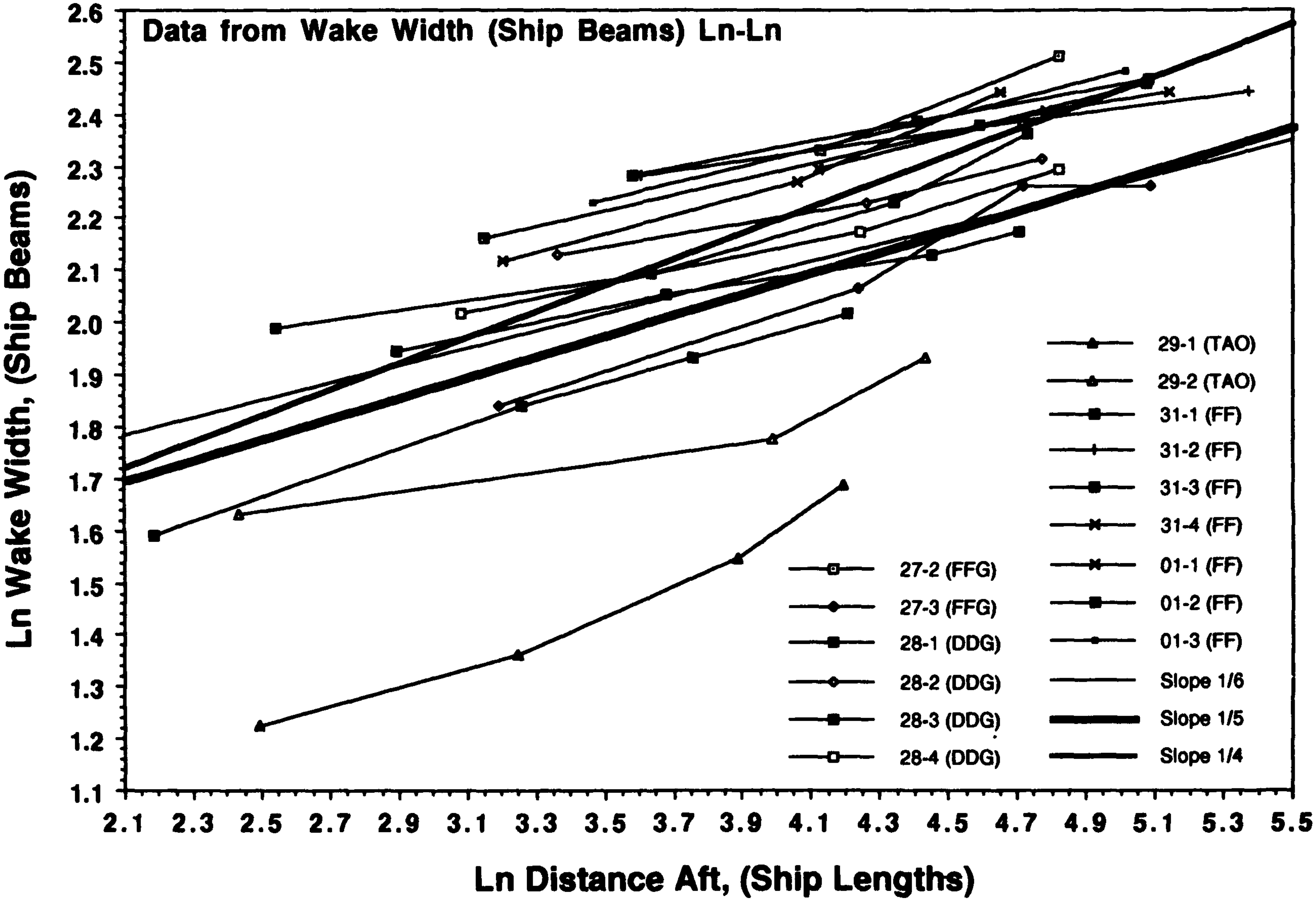


Figure 27. Summary plot of all of the measured surfactant wake width data obtained during the 1989 ONR Field Experiment.

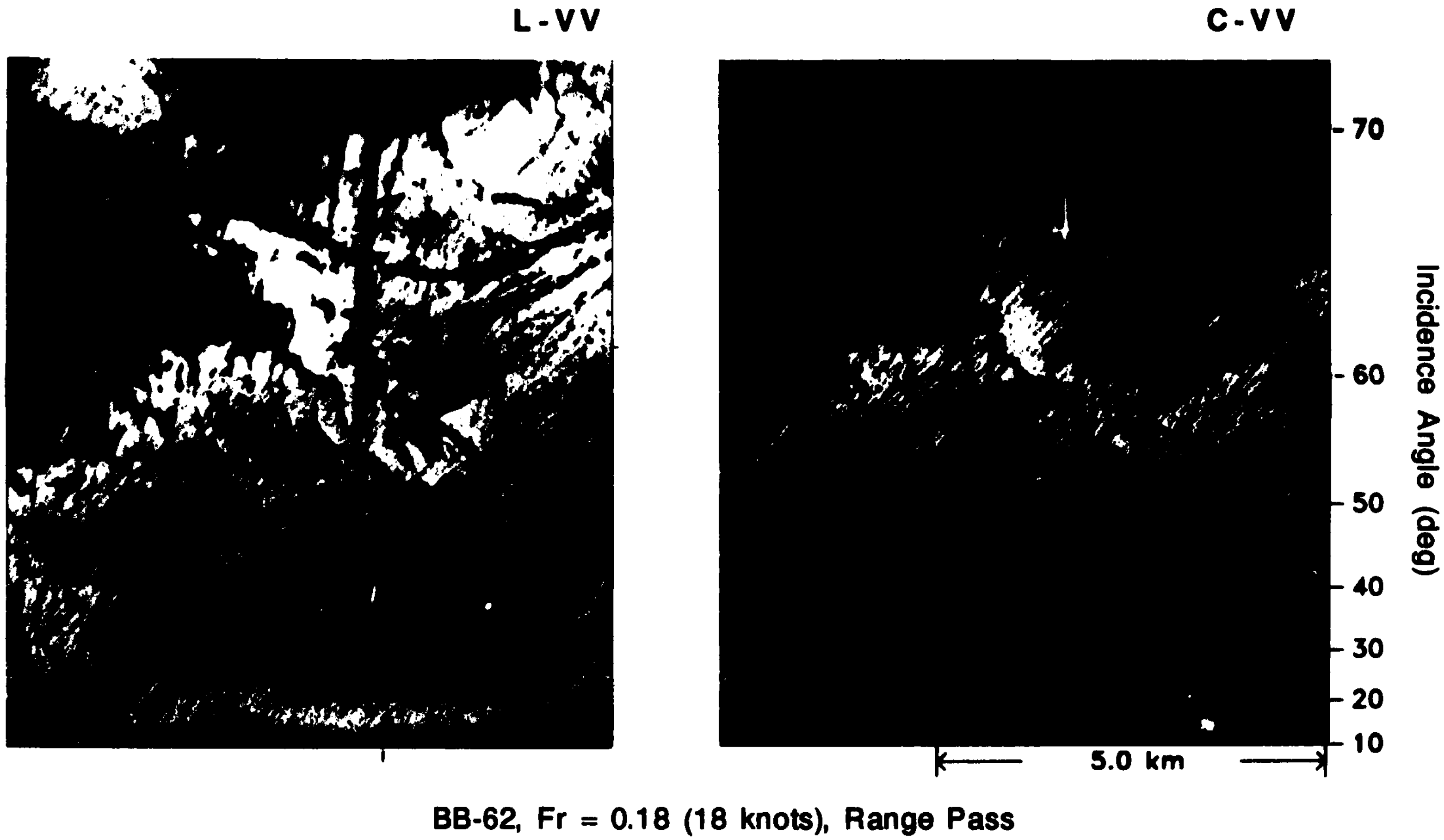
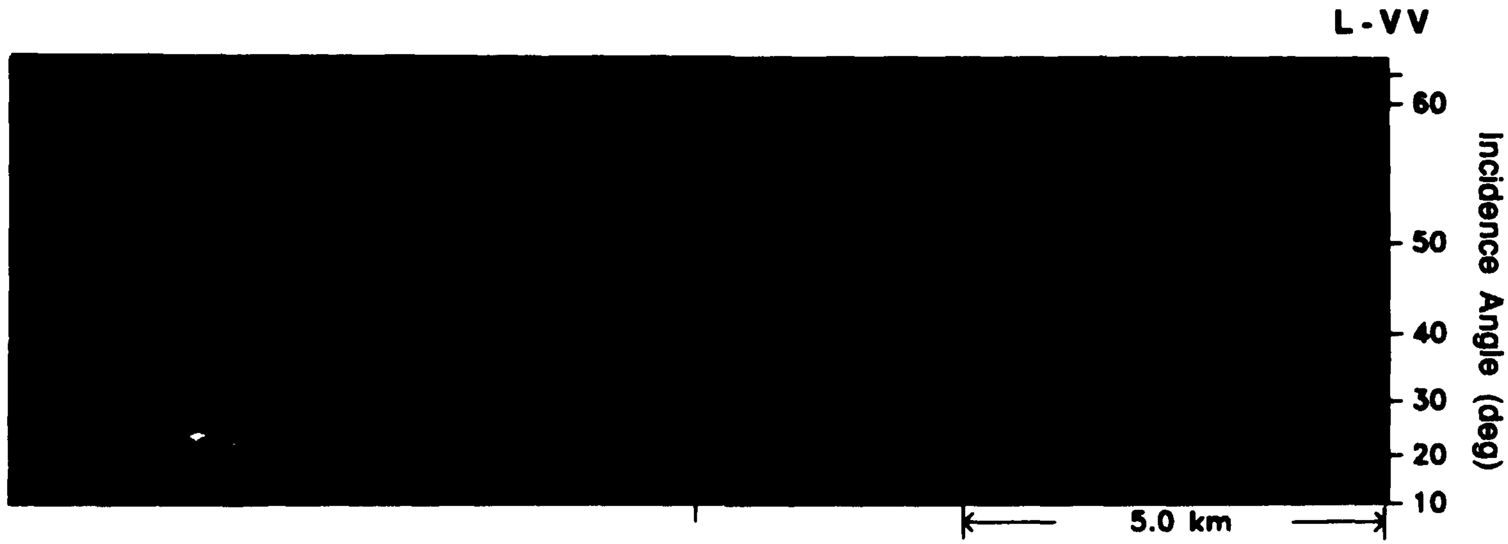


Figure 28. L- and C-band airborne SAR images of a Navy battleship travelling in the range direction during the 1989 ONR Field Experiment. The ship speed is 18 knots, or 9.3 m/s. (Courtesy of D. Hogge, Arete Associates.)



DDG-996, Fr = 0.324 (25 Knots), Azimuth Pass

Figure 29. L-band airborne SAR image of a Navy destroyer travelling in the azimuthal direction during the 1989 ONR Field Experiment. The ship speed is 25 knots, or 12.9 m/s. (Courtesy of D. Hogge, Arete Associates.)

of the ship clearly is visible in the image, but it no longer is displaced from the dark centerline wake which extends far downstream from the vessel. There are several notable hydrodynamic features in the SAR image. First is the distinct dark centerline wake feature already noted, which represents a relative absence of the short wavelength surface scatterers. There also are bright features of enhanced radar backscatter return which include a narrow-V arm on the port side of the ship, and both transverse and divergent Kelvin waves. Narrow bright-line regions of radar backscatter return are visible adjacent to the dark centerline wake just downstream of the ship. These have been attributed to soliton wake features and breaking waves. The ambient background return in this SAR image shows far less variabilitiy than did the images in Figure 28. The two imaging experiments were conducted four days apart at essentially the same open ocean site near Santa Cruz Island.

Two Navy frigates are shown travelling at 25 knots in the azimuthal direction in the L-band SAR image of Figure 30. Again there are several distinct features in the radar image. These include the dark centerline wakes which extend downstream for numerous ship lengths for both vessels. The wake of the vessel on the left appears to be wider and to extend further aft than does the wake of the center vessel. In this image there are both bright (port) and dark (starboard) narrow-V features which appear together with the divergent waves of the Kelvin wakes of the two ships. The bright arm of the Kelvin pattern is toward the windward side of the wake and gives some evidence of the presence of breaking waves. Here the ambient ocean background shows some variability, with a dark zone of reduced radar backscatter in the left hand portion of the image, a zone of long-crested swell covering the right hand portion, and a distinct boundary between the two zones.

The primary mechanism by which surfactants contribute to a SAR image or other radar images of the ocean surface is through wave damping, and two important variables in this process are the Bragg scattering wave number (if the radar incidence angle is not too large or too small) and the surface film elasticity as described in the preceding sections of this report. The measurements and comparisons with observations compiled in this report, and in several related related reports and papers demonstrate that surface-active materials which have been redistributed into compacted film bands in the ship wake play an important role in the formation and persistence of the centerline wake and "railroad track" features so detectable in the SAR images of ship wakes.

FF-1067 and FFG-10, Fr = 0.37 (25 Knots), Azimuth Pass

Figure 30. L-band airborne SAR image of two Navy frigates (FF left, FFG center) travelling in the azimuthal direction during the 1989 ONR Field Experiment. The ships' speeds are 25 knots, or 12.9 m/s. (Courtesy of D. Hogge, Arete Associates.)

The role of the surfactants is probably the *dominant one* in the far-field surface wake. In the near-field wake region there are numerous other complex factors whose combined influences on the wave energy distribution cannot be neglected. This archive of surfactant film measurements from the 1989 ONR Field Experiment will provide an important resource for the utilization of high resolution ship wake information in the demonstration of ship and ship wake detection and classification systems.

6.0 REFERENCES

Adam, N.K., A rapid method for determining the lowering of tension of exposed water surfaces, with some observations on the surface tension of the sea and inland waters, *Proc. R. Soc. London, Ser. B, 122*, 134-139, 1937.

Barger, W.R., and M.A. Klusty, Common features of natural surface films from the coastal waters of Maine, Virginia, and Bermuda, I, Pressure and modulus data, *J. Geophys. Res.*, in press, 1992.

Barger, W.R., and J.C. Means, Clues to the structure of marine organic material from the study of physical properties of surface films, in *Marine and Estuarine Geochemistry*, edited by A. C. Sigleo and A. Hattori, pp. 44-67, Lewis, Chelsea, Mich., 1985.

Barger, W.R., J.A.C. Kaiser, and M.A. Klusty, Physical effects of sea surface microlayer films collected from the coastal waters of Maine, Virginia and Bermuda (abstract), *EOS Trans. AGU, 69*(44), 1095, 1988.

Bonmarin, P., Geometric properties of deep-water breaking waves, *J. Fluid Mech., 209*, 405-433, 1989.

Dorrestein, R., General linearized theory of the effect of surface films on water ripples, *Proc. K. Ned. Akad. Wet., 54*, 260-350, 1951.

Frew, N.M., J.C. Goldman, M.R. Dennett, and A.S. Johnson, Impact of phytoplankton-generated surfactants on air-sea gas exchange, *J. Geophys. Res., 95*(C3), 3337-3352, 1990.

Garrett, W.D., Damping of capillary waves at the air-sea interface by oceanic surface-active material, *J. Mar. Res., 25*, 279-291, 1967.

Garrett, W.D., and R.A. Duce, Surface microlayer samplers, *Air-Sea Interaction Instruments and Methods*, edited by F. Dobson, L. Hasse, and R. Davis, pp. 471-490, Plenum, New York, 1980.

Gasparovic, R.F. and D.H. Johnson, OCNR Ship Wake Experiment. Centerline Wake Physics and Kelvin Wake Observability (U), *JHU/APL Report S1R-91S-004, Volumes I-III*, August 1991 (SECRET).

Griffin, O.M., R.D. Peltzer, A.M. Reed, and R.F. Beck, Remote Sensing of Surface Ship Wakes, *Naval Engineers Journal, 104* 245-258, 1992.

Hasselmann, K., On the nonlinear energy transfer in a gravity wave spectrum, 1, General theory, *J. Fluid Mech., 12*, 481-500, 1962.

Huhnerfuss, H., W. Alpers, W.L. Jones, P.A. Lange, and K. Richter, The damping of ocean surface waves by a monomolecular film measured by wave staffs and microwave radars, *J. Geophys. Res., 86*(C1), 429-438, 1981.

Kaiser, J.A.C., S.E. Ramberg, R.D. Peltzer, M.D. Andrews, and W.D. Garrett, Wakex 86, A ship wake/films exploratory experiment, *NRL Memo. Rep. 6270*, Nav. Res. Lab., Washington, D. C., 55 pp., 1988.

Kitaigorodskii, S.A., and J.L. Lumley, Wave-turbulence interactions in the upper ocean, I, The energy balance of the interacting fields of surface wind waves and wind-induced three-dimensional turbulence, *J. Phys. Oceanogr., 13*, 1977-1987, 1983.

Kitaigorodskii, S.A., M.A. Donelan, J.L. Lumley, and E.A. Teray, Wave-turbulence interactions in the upper ocean, II, Statistical characteristics of wave and turbulent components of the random velocity field in the marine surface layer, *J. Phys. Oceanogr., 13,* 1988-1998, 1983.

Lyden, J.D., R.R. Hammond, D.R. Lyzenga, and R.A. Shuchman, Synthetic aperture radar imaging of surface ship wakes, *J. Geophys. Res., 93*(C10), 12,293-12,303, 1988.

Milgram, J.H., R.D. Peltzer and O.M. Griffin, Suppression of Short Sea Waves in Ship Wakes-Measurements and Observations, *J. Geophys. Res., 98*(C4), 7103-7114, 1993a.

Milgram, J.H., R.A. Skop, R.D. Peltzer and O.M. Griffin, Modelling Short Sea Wave Energy Distributions in the Far Wakes of Ships, *J. Geophys. Res., 98*(C4), 7115-7124, 1993b.

Mitsuyasu, H., and T. Honda, Wind-induced growth of water waves, *J. Fluid Mech., 123,* 425-442, 1982.

National Defense Research Committee, Physics of sound in the sea, IV, Acoustic properties of wakes, Summary technical report of division 6, vol. 8, Washington, D. C., 1946. (Reprinted as *NAVMAT Rep. P-9675,* Naval Material Command, Washington, D. C., 1969.)

Ochadlick, A.R., Jr., W.A. Schmidt, and P. Cho, Quantitative stability of slicks observed with the NADC SAR during SAXON (abstract), *EOS Trans. AGU, 71*(2), 83, 1990.

Olmez, H.S., and J.H. Milgram, An experimental study of attenuation of short water waves by turbulence, report, Dep. of Ocean Eng., Mass. Inst. of Technol., Cambridge, Mass., 1990.

Peltzer, R.D., White-water wake characteristics of surface vessels, *NRL Memo. Rep. 5335,* 96 pp., Nav. Res. Lab., Washington, D. C., 1984.

Peltzer, R.D., J.H. Milgram, R.A. Skop, J.A.C. Kaiser, O.M. Griffin and W.R. Barger, Hydrodynamics of ship wake surfactant films, 18th Symposium on Naval Hydrodynamics, 533-552, Nat. Acad. Press, Washington, D. C., 1991.

Peltzer, R.D., O.M. Griffin, W.R. Barger and J.A.C. Kaiser, High-Resolution Measurement of Surface-Active Film Redistribution in Ship Wakes, *J. Geophys. Res., 97,* (C4), 5231-5252, 1992.

Phillips, O.M., The scattering of gravity waves by turbulence, *J. Fluid Mech., 5*(12), 177-192, 1958.

Plant, W.J., A relationship between wind stress and wave slope, *J. Geophys. Res., 87*(C3), 1961-1967, 1982.

Ramberg, S.E., and O.M. Griffin, Laboratory study of steep and breaking deep water waves, *J. Waterw. Port Coastal Ocean Eng., Div. Am. Soc. Civ. Eng., 113*(OE-5), 493-506, 1987.

Reed, A.M., R.F. Beck, O.M. Griffin, and R.D. Peltzer, Hydrodynamics of remotely sensed surface ship wakes, *Soc. Nav. Arch. Mar. Eng. Trans., 98,*, 319-363, 1990.

Scully-Power, P., Navy oceanographer shuttle observations, *Rep. STS 41-G, NUSC Tech. Doc. 7611,* Nav. Underw. Syst. Cent., Newport, R. I., 1986.

Skop, R.A., O.M. Griffin, and Y. Leipold, Modification of directional wave number spectra by currents in the wake of a surface ship, *J. Ship Res., 34,* 69-78, 1990.

Skop, R.A., W.G. Lindsley, and J.W. Brown, Radiotracer studies of surfactant transport to the sea-air interface by submillimeter-size bubbles, *Exp. Fluids, 10,* 251-256, 1991.

Vesecky, J.F., and R.H. Stewart, The observation of ocean surface phenomena using imagery from the Seasat synthetic aperture radar: An assessment, *J. Geophys. Res., 87*(C5), 3397-3430, 1982.

7.0 APPENDICES

Appendix 7.1. Surfactant Film Data Base Archive

Appendix 7.1.

The following is a consolidated summary of all the figures and data file listings that are contained in the seven data notebooks. Each of the individual sections in the notebook are separated by a bold face header. Individual figures or data file listings in these sections are denoted by the numbers at the beginning of each paragraph following the bold face header. Individual file names listed in this appendix generally contain descriptions of the contents and type of the file. The majority of the files are coded as follows; [XXYZ.description], where XX is the number of days into the field test (Jan. 23, 1989 is day 1 and Feb 1, 1989 is day 10), Y is the Run module number completed by the Navy Target Ship during the operations on that given day (Runs 1-4), and Z is the number of the wake crossing (or leg) completed by the NRL STEMS during that Run (crossings or legs 1-4).

Day 5 (1/27/89): Runs 2, 3

1. Wake crossing data tables (Microsoft Powerpoint format): Runs 2 and 3. The data are stored in file 1.27.89(2,3).
2. Ln-Ln plot of surfactant wake width vs. distance aft of the ship for all of the runs completed during the day. The plot file is wwday5.grf, and the data are stored in [Wake Width (B) Ln-Ln].
3. Surface tension and film pressure vs. area graphs for all the water samples taken during the morning runs. The plot files are SurfTens/area.composite and FilmPress/area.composite.
4. Tabulated listings (Microsoft Word and Cricket Graph spread sheet format) of the potential, surface tension, and film pressure vs. area values for the water samples taken during the morning runs. The Cricket Graph data files are Parea26.24hrs0920am, Parea28.18hrs0745am, Parea29a.18hrs1155am and Parea29b.18hrs0730am. The MS Word data files are FP26.MSWord, FP28.MSWord, FP29a.MSWord and FP29b.MSWord.

Run 2 (1/27/89): Legs 1, 2, 3

1. Combined plot: Surface tension vs. time for Legs 1, 2, and 3. The three files plotted are 521.STensiontimec, 522.STensiontimec, and 523.STensiontimec.2. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, and 3. The cross-wake distance scale is 400m. The three files plotted are 521.STension400m, 522.STension400m, and 523.STension400m.
3. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, and 3. The cross-wake distance scale is 240m. The three files plotted are 521.STension240m, 522.STension240m, and 523.STension240m.
4. PMTC tracking plot of STEMS location during Run 2. There is no data file for this plot. It is a hard copy graph from JHUAPL.
5. Tabulated STEMS velocity values (Microsoft Word format) that were obtained from the PMTC tracking plots, listed in 1 minute intervals during Run 2. The name of the MS Word file is Day5Run2.velocity.

Run 2, Leg 1, (1/27/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 1 plus supporting data. The plot file name is 521.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 400m. The plot file name is 521.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 240m. The plot file name is 521.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 1. The three files plotted are 521.STension400m, 521.FilmPressgraph, and 521.Elasticitygraph.

5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 1. The file name is 521.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 1. The file name is 521.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 1. The file name is 521.STensionData.

Run 2, Leg 2, (1/27/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 2 plus supporting data. The plot file name is 522.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 400m. The plot file name is 522.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 240m. The plot file name is 522.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 2. The three files plotted are 522.STension400m, 522.FilmPressgraph, and 522.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 2. The file name is 522.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 2. The file name is 522.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 2. The file name is 522.STensionData.

Run 2, Leg 3, (1/27/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 3 plus supporting data. The plot file name is 523.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3 The cross-wake distance scale is 400m. The plot file name is 523.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3. The cross-wake distance scale is 240m. The plot file name is 523.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 3 The three files plotted are 523.STension400m, 523.FilmPressgraph, and 523.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 3. The file name is 523.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 3 The file name is 523.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 3. The file name is 523.STensionData.

Run 3 (1/27/89): Legs 1, 2, 3, 4

1. Combined plot: Surface tension vs. time for Legs 1, 2, 3, and 4. The four files plotted are 531.STensiontimec, 532.STensiontimec, 533.STensiontimec and 534.STensiontimec.

2. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, 3, and 4. The cross-wake distance scale is 400m. The four files plotted are 531.STension400m, 532.STension400m, 533.STension400m, and 534.STension400m.
3. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, 3, and 4. The cross-wake distance scale is 240m. The four files plotted are 531.STension240m, 532.STension240m, 533.STension240m, and 534.STension240m.
4. PMTC tracking plot of STEMS location during Run 3. There is no data file for this plot. It is a hard copy graph from JHUAPL.
5. Tabulated STEMS velocity values (Microsoft Word format) that were obtained from the PMTC tracking plots, listed in 1 minute intervals during Run 2. The name of the MS Word file is Day5Run3.velocity.

Run 3, Leg 1, (1/27/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 1 plus supporting data. The plot file name is 531.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 400m. The plot file name is 531.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 240m. The plot file name is 531.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 1. The three files plotted are 531.STension400m, 531.FilmPressgraph, and 531.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 1. The file name is 531.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 1. The file name is 531.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 1. The file name is 531.STensionData.

Run 3, Leg 2, (1/27/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 2 plus supporting data. The plot file name is 532.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 400m. The plot file name is 532.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 240m. The plot file name is 532.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 2. The three files plotted are 532.STension400m, 532.FilmPressgraph, and 532.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 2. The file name is 532.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 2. The file name is 532.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 2. The file name is 532.STensionData.

Run 3, Leg 3, (1/27/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 3 plus supporting data. The plot file name is 533.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3 The cross-wake distance scale is 400m. The plot file name is 533.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3. The cross-wake distance scale is 240m. The plot file name is 533.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 3 The three files plotted are 533.STension400m, 533.FilmPressgraph, and 533.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 3. The file name is 533.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 3 The file name is 533.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 3. The file name is 533.STensionData.

Run 3, Leg 4, (1/27/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 4 plus supporting data. The plot file name is 534STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 4 The cross-wake distance scale is 400m. The plot file name is 534.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 4. The cross-wake distance scale is 240m. The plot file name is 534.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 4 The three files plotted are 534.STension400m, 534.FilmPressgraph, and 534.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 4 The file name is 534CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 4 The file name is 534.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 4. The file name is 534.STensionData.

Day 6 (1/28/89): Runs 1, 3

1. Wake crossing data tables (Microsoft Powerpoint format): Runs 1 and 3. The data are stored in file 1.28.89(1,3).
2. Ln-Ln plot of surfactant wake width vs. distance aft of the ship for all of the runs completed during the day. The plot file is wwday6.grf, and the data are stored in [Wake Width (B) Ln-Ln].
3. Surface tension and film pressure vs. area graphs for all the water samples taken during the morning runs. The plot files are SurfTens/area.composite and FilmPress/area.composite.
4. Tabulated listings (Microsoft Word and Cricket Graph spread sheet format) of the potential, surface tension, and film pressure vs. area values for the water samples taken during the morning runs. The Cricket Graph data files are Parea26.24hrs0920am, Parea28.18hrs0745am, Parea29a.18hrs1155am and Parea29b.18hrs0730am. The MS Word data files are FP26.MSWord, FP28.MSWord, FP29a.MSWord and FP29b.MSWord.

Day 6 (1/28/89): Runs 2, 4

1. Wake crossing data tables (Microsoft Powerpoint format): Runs 2 and 4. The data are stored in file 1.28.89(2,4).
2. Ln-Ln plot of surfactant wake width vs. distance aft of the ship for all of the runs completed during the day. The plot file is wwday6.grf, and the data are stored in [Wake Width (B) Ln-Ln].
3. Surface tension and film pressure vs. area graphs for all the water samples taken during the morning runs. The plot files are SurfTens/area.composite and FilmPress/area.composite.
4. Tabulated listings (Microsoft Word and Cricket Graph spread sheet format) of the potential, surface tension, and film pressure vs. area values for the water samples taken during the morning runs. The Cricket Graph data files are Parea26.24hrs0920am, Parea28.18hrs0745am, Parea29a.18hrs1155am and Parea29b.18hrs0730am. The MS Word data files are FP26.MSWord, FP28.MSWord, FP29a.MSWord and FP29b.MSWord.

Run 1 (1/28/89): Legs 1, 2, 3, 4

1. Combined plot: Surface tension vs. time for Legs 1, 2, 3, and 4. The four files plotted are 611.STensiontimec, 612.STensiontimec, 613.STensiontimec and 614.STensiontimec.
2. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, 3, and 4. The cross-wake distance scale is 400m. The four files plotted are 611.STension400m, 612.STension400m, 613.STension400m, and 614.STension400m.
3. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, 3, and 4. The cross-wake distance scale is 240m. The four files plotted are 611.STension240m, 612.STension240m, 613.STension240m, and 614.STension240m.
4. PMTC tracking plot of STEMS location during Run 1. There is no data file for this plot. It is a hard copy graph from JHUAPL.
5. Tabulated STEMS velocity values (Microsoft Word format) that were obtained from the PMTC tracking plots, listed in 1 minute intervals during Run 1. The name of the MS Word file is Day6Run1.velocity.

Run 1, Leg 1, (1/28/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 1 plus supporting data. The plot file name is 611.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 400m. The plot file name is 611.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 240m. The plot file name is 611.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 1. The three files plotted are 611.STension400m, 611.FilmPressgraph, and 611.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 1. The file name is 611.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 1. The file name is 611.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 1. The file name is 611.STensionData.

Run 1, Leg 2, (1/28/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 2 plus supporting data. The plot file name is 612.STensiontime.

2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 400m. The plot file name is 612.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 240m. The plot file name is 612.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 2. The three files plotted are 612.STension400m, 612.FilmPressgraph, and 612.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 2. The file name is 612.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 2. The file name is 612.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 2. The file name is 612.STensionData.

Run 1, Leg 3, (1/28/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 3 plus supporting data. The plot file name is 613.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3 The cross-wake distance scale is 400m. The plot file name is 613.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3. The cross-wake distance scale is 240m. The plot file name is 613.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 3 The three files plotted are 613.STension400m, 613.FilmPressgraph, and 613.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 3. The file name is 613.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 3 The file name is 613.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 3. The file name is 613.STensionData.

Run 1, Leg 4, (1/28/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 4 plus supporting data. The plot file name is 614STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 4 The cross-wake distance scale is 400m. The plot file name is 614.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 4. The cross-wake distance scale is 240m. The plot file name is 614.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 4 The three files plotted are 614.STension400m, 614.FilmPressgraph, and 614.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 4 The file name is 614CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 4 The file name is 614.MSWord.

7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 4. The file name is 614.STensionData.

Run 2 (1/28/89): Legs 1, 2, 3

1. Combined plot: Surface tension vs. time for Legs 1, 2, and 3. The three files plotted are 621.STensiontimec, 622.STensiontimec, and 623.STensiontimec.
2. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, and 3. The cross-wake distance scale is 400m. The three files plotted are 621.STension400m, 622.STension400m, and 623.STension400m.
3. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, and 3. The cross-wake distance scale is 240m. The three files plotted are 621.STension240m, 622.STension240m, and 623.STension240m.
4. PMTC tracking plot of STEMS location during Run 2. There is no data file for this plot. It is a hard copy graph from JHUAPL.
5. Tabulated STEMS velocity values (Microsoft Word format) that were obtained from the PMTC tracking plots, listed in 1 minute intervals during Run 2. The name of the MS Word file is Day6Run2.velocity.

Run 2, Leg 1, (1/28/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 1 plus supporting data. The plot file name is 621.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 400m. The plot file name is 621.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 240m. The plot file name is 621.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 1. The three files plotted are 621.STension400m, 621.FilmPressgraph, and 621.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 1. The file name is 621.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 1. The file name is 621.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 1. The file name is 621.STensionData.

Run 2, Leg 2, (1/28/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 2 plus supporting data. The plot file name is 622.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 400m. The plot file name is 622.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 240m. The plot file name is 622.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 2. The three files plotted are 622.STension400m, 622.FilmPressgraph, and 622.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 2. The file name is 622.CutElasticity.

6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 2. The file name is 622.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 2. The file name is 622.STensionData.

Run 2, Leg 3, (1/28/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 3 plus supporting data. The plot file name is 623.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3 The cross-wake distance scale is 400m. The plot file name is 623.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3. The cross-wake distance scale is 240m. The plot file name is 623.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 3 The three files plotted are 623.STension400m, 623.FilmPressgraph, and 623.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 3. The file name is 623.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 3 The file name is 623.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 3. The file name is 623.STensionData.

Run 3 (1/28/89): Legs 1, 2, 3, 4

1. Combined plot: Surface tension vs. time for Legs 1, 2, 3, and 4. The four files plotted are 631.STensiontimec, 632.STensiontimec, 633.STensiontimec and 634.STensiontimec.
2. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, 3, and 4. The cross-wake distance scale is 400m. The four files plotted are 631.STension400m, 632.STension400m. 633.STension400m, and 634STension400m.
3. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, 3, and 4. The cross-wake distance scale is 240m. The four files plotted are 521.STension240m, 522.STension240m, 523.STension240m, and 524.STension240m.
4. PMTC tracking plot of STEMS location during Run 3. There is no data file for this plot. It is a hard copy graph from JHUAPL.
5. Tabulated STEMS velocity values (Microsoft Word format) that were obtained from the PMTC tracking plots, listed in 1 minute intervals during Run 3. The name of the MS Word file is Day6Run3.velocity.

Run 3, Leg 1, (1/28/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 1 plus supporting data. The plot file name is 631.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 400m. The plot file name is 631.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 240m. The plot file name is 631.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 1. The three files plotted are 631.STension400m, 631.FilmPressgraph, and 631.Elasticitygraph.

5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 1. The file name is 631.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 1. The file name is 631.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 1. The file name is 631.STensionData.

Run 3, Leg 2, (1/28/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 2 plus supporting data. The plot file name is 632.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 400m. The plot file name is 632.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 240m. The plot file name is 632.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 2. The three files plotted are 632.STension400m, 632.FilmPressgraph, and 632.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 2. The file name is 632.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 2. The file name is 632.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 2. The file name is 632.STensionData.

Run 3, Leg 3, (1/28/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 3 plus supporting data. The plot file name is 633.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3 The cross-wake distance scale is 400m. The plot file name is 633.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3. The cross-wake distance scale is 240m. The plot file name is 633.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 3. The three files plotted are 633.STension400m, 633.FilmPressgraph, and 633.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 3. The file name is 633.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 3. The file name is 633.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 3. The file name is 633.STensionData.

Run 3, Leg 4, (1/28/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 4 plus supporting data. The plot file name is 634STensiontime.

2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 4 The cross-wake distance scale is 400m. The plot file name is 634.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 4. The cross-wake distance scale is 240m. The plot file name is 634.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 4 The three files plotted are 634.STension400m, 634.FilmPressgraph, and 634.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 4 The file name is 634CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 4 The file name is 634.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 4. The file name is 634.STensionData.

Run 4 (1/28/89): Legs 1, 2, 3

1. Combined plot: Surface tension vs. time for Legs 1, 2, and 3. The three files plotted are 641.STensiontimec, 642.STensiontimec, and 643.STensiontimec.
2. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, and 3. The cross-wake distance scale is 400m. The three files plotted are 641.STension400m, 642.STension400m, and 643.STension400m.
3. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, and 3. The cross-wake distance scale is 240m. The three files plotted are 641.STension240m, 642.STension240m, and 643.STension240m.
4. PMTC tracking plot of STEMS location during Run 4. There is no data file for this plot. It is a hard copy graph from JHUAPL.
5. Tabulated STEMS velocity values (Microsoft Word format) that were obtained from the PMTC tracking plots, listed in 1 minute intervals during Run 4. The name of the MS Word file is Day6Run4.velocity.

Run 4, Leg 1, (1/28/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 1 plus supporting data. The plot file name is 641.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 400m. The plot file name is 641.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 240m. The plot file name is 641.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 1. The three files plotted are 641.STension400m, 641.FilmPressgraph, and 641.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 1. The file name is 641.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 1. The file name is 641.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 1. The file name is 641.STensionData.

Run 4, Leg 2, (1/28/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 2 plus supporting data. The plot file name is 642.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 400m. The plot file name is 642.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 240m. The plot file name is 642.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 2. The three files plotted are 642.STension400m, 642.FilmPressgraph, and 642.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 2. The file name is 642.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 2. The file name is 642.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 2. The file name is 642.STensionData.

Run 4, Leg 3, (1/28/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 3 plus supporting data. The plot file name is 643.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3 The cross-wake distance scale is 400m. The plot file name is 643.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3. The cross-wake distance scale is 240m. The plot file name is 643.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 3 The three files plotted are 643.STension400m, 643.FilmPressgraph, and 643.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 3. The file name is 643.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 3 The file name is 643.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 3. The file name is 643.STensionData.

Day 7 (1/29/89): Runs 1, 2

1. Wake crossing data tables (Microsoft Powerpoint format): Runs 1 and 2. The data are stored in file 1.29.89(1,2).
2. Ln-Ln plot of surfactant wake width vs. distance aft of the ship for all of the runs completed during the day. The plot file is wwday7.grf, and the data are stored in [Wake Width (B) Ln-Ln].
3. Surface tension and film pressure vs. area graphs for all the water samples taken during the morning runs. The plot files are SurfTens/area.composite and FilmPress/area.composite.
4. Tabulated listings (Microsoft Word and Cricket Graph spread sheet format) of the potential, surface tension, and film pressure vs. area values for the water samples taken during the morning runs. The Cricket Graph data files are Parea26.24hrs0920am, Parea28.18hrs0745am, Parea29a.18hrs1155am and Parea29b.18hrs0730am. The MS Word data files are FP26.MSWord, FP28.MSWord, FP29a.MSWord and FP29b.MSWord.

Run 1 (1/29/89): Legs 1, 2, 3, 4

1. Combined plot: Surface tension vs. time for Legs 1, 2, 3, and 4. The four files plotted are 711.STensiontimec, 712.STensiontimec, 713.STensiontimec and 714.STensiontimec.
2. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, 3, and 4. The cross-wake distance scale is 400m. The four files plotted are 711.STension400m, 712.STension400m, 713.STension400m, and 714.STension400m.
3. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, 3, and 4. The cross-wake distance scale is 240m. The four files plotted are 711.STension240m, 712.STension240m, 713.STension240m, and 714.STension240m.
4. PMTC tracking plot of STEMS location during Run 1. There is no data file for this plot. It is a hard copy graph from JHUAPL.
5. Tabulated STEMS velocity values (Microsoft Word format) that were obtained from the PMTC tracking plots, listed in 1 minute intervals during Run 1. The name of the MS Word file is Day7Run1.velocity.

Run 1, Leg 1, (1/29/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 1 plus supporting data. The plot file name is 711.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 400m. The plot file name is 711.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 240m. The plot file name is 711.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 1. The three files plotted are 711.STension400m, 711.FilmPressgraph, and 711.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 1. The file name is 711.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 1. The file name is 711.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 1. The file name is 711.STensionData.

Run 1, Leg 2, (1/29/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 2 plus supporting data. The plot file name is 712.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 400m. The plot file name is 712.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 240m. The plot file name is 712.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 2. The three files plotted are 712.STension400m, 712.FilmPressgraph, and 712.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 2. The file name is 712.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 2. The file name is 712.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 2. The file name is 712.STensionData.

Run 1, Leg 3, (1/29/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 3 plus supporting data. The plot file name is 713.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3 The cross-wake distance scale is 400m. The plot file name is 713.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3. The cross-wake distance scale is 240m. The plot file name is 713.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 3 The three files plotted are 713.STension400m, 713.FilmPressgraph, and 713.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 3. The file name is 713.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 3 The file name is 713.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 3. The file name is 713.STensionData.

Run 1, Leg 4, (1/29/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 4 plus supporting data. The plot file name is 714STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 4 The cross-wake distance scale is 400m. The plot file name is 714.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 4. The cross-wake distance scale is 240m. The plot file name is 714.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 4 The three files plotted are 714.STension400m, 714.FilmPressgraph, and 714.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 4 The file name is 714CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 4 The file name is 714.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 4. The file name is 714.STensionData.

Run 2 (1/29/89): Legs 1, 2, 3

1. Combined plot: Surface tension vs. time for Legs 1, 2, and 3. The three files plotted are 721.STensiontimec, 722.STensiontimec, and 723.STensiontimec.
2. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, and 3. The cross-wake distance scale is 400m. The three files plotted are 721.STension400m, 722.STension400m, and 723.STension400m.
3. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, and 3. The cross-wake distance scale is 240m. The three files plotted are 721.STension240m, 722.STension240m, and723.STension240m.
4. PMTC tracking plot of STEMS location during Run 2. There is no data file for this plot. It is a hard copy graph from JHUAPL.

5. Tabulated STEMS velocity values (Microsoft Word format) that were obtained from the PMTC tracking plots, listed in 1 minute intervals during Run 2. The name of the MS Word file is Day7Run2.velocity.

Run 2, Leg 1, (1/29/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 1 plus supporting data. The plot file name is 721.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 400m. The plot file name is 721.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 240m. The plot file name is 721.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 1. The three files plotted are 721.STension400m, 721.FilmPressgraph, and 721.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 1. The file name is 721.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 1. The file name is 721.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 1. The file name is 721.STensionData.

Run 2, Leg 2, (1/29/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 2 plus supporting data. The plot file name is 722.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 400m. The plot file name is 722.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 240m. The plot file name is 722.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 2. The three files plotted are 722.STension400m, 722.FilmPressgraph, and 722.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 2. The file name is 722.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 2. The file name is 722.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 2. The file name is 722.STensionData.

Run 2, Leg 3, (1/29/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 3 plus supporting data. The plot file name is 723.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3 The cross-wake distance scale is 400m. The plot file name is 723.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3. The cross-wake distance scale is 240m. The plot file name is 723.STension240m.

4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 3 The three files plotted are 723.STension400m, 723.FilmPressgraph, and 723.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 3. The file name is 723.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 3 The file name is 723.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 3. The file name is 723.STensionData.

Day 9 (1/31/89): Runs 1, 3

1. Wake crossing data tables (Microsoft Powerpoint format): Runs 1 and 3. The data are stored in file 1.29.89(1,3).
2. Ln-Ln plot of surfactant wake width vs. distance aft of the ship for all of the runs completed during the day. The plot file is wwday9.grf, and the data are stored in [Wake Width (B) Ln-Ln].
3. Surface tension and film pressure vs. area graphs for all the water samples taken during the morning runs. The plot files are SurfTens/area.composite and FilmPress/area.composite.
4. Tabulated listings (Microsoft Word and Cricket Graph spread sheet format) of the potential, surface tension, and film pressure vs. area values for the water samples taken during the morning runs. The Cricket Graph data files are Parea26.24hrs0920am, Parea28.18hrs0745am, Parea29a.18hrs1155am and Parea29b.18hrs0730am. The MS Word data files are FP26.MSWord, FP28.MSWord, FP29a.MSWord and FP29b.MSWord.

Day 9 (1/31/89): Runs 2, 4

1. Wake crossing data tables (Microsoft Powerpoint format): Runs 2 and 4. The data are stored in file 1.31.89(2,4).
2. Ln-Ln plot of surfactant wake width vs. distance aft of the ship for all of the runs completed during the day. The plot file is wwday9.grf, and the data are stored in [Wake Width (B) Ln-Ln].
3. Surface tension and film pressure vs. area graphs for all the water samples taken during the morning runs. The plot files are SurfTens/area.composite and FilmPress/area.composite.
4. Tabulated listings (Microsoft Word and Cricket Graph spread sheet format) of the potential, surface tension, and film pressure vs. area values for the water samples taken during the morning runs. The Cricket Graph data files are Parea26.24hrs0920am, Parea28.18hrs0745am, Parea29a.18hrs1155am and Parea29b.18hrs0730am. The MS Word data files are FP26.MSWord, FP28.MSWord, FP29a.MSWord and FP29b.MSWord.

Run 1 (1/31/89): Legs 1, 2, 3, 4

1. Combined plot: Surface tension vs. time for Legs 1, 2, 3, and 4. The four files plotted are 911.STensiontimec, 912.STensiontimec, 913.STensiontimec and 914.STensiontimec.
2. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, 3, and 4. The cross-wake distance scale is 400m. The four files plotted are 911.STension400m, 912.STension400m, 913.STension400m, and 914.STension400m.
3. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, 3, and 4. The cross-wake distance scale is 240m. The four files plotted are 911.STension240m, 912.STension240m, 913.STension240m, and 914.STension240m.
4. PMTC tracking plot of STEMS location during Run 1. There is no data file for this plot. It is a hard copy graph from JHUAPL.
5. Tabulated STEMS velocity values (Microsoft Word format) that were obtained from the PMTC tracking plots, listed in 1 minute intervals during Run 1. The name of the MS Word file is Day9Run1.velocity.

Run 1, Leg 1, (1/31/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 1 plus supporting data. The plot file name is 911.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 400m. The plot file name is 911.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 240m. The plot file name is 911.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 1. The three files plotted are 911.STension400m, 911.FilmPressgraph, and 911.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 1. The file name is 911.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 1. The file name is 911.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 1. The file name is 911.STensionData.

Run 1, Leg 2, (1/31/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 2 plus supporting data. The plot file name is 912.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 400m. The plot file name is 912.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 240m. The plot file name is 912.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 2. The three files plotted are 912.STension400m, 912.FilmPressgraph, and 912.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 2. The file name is 912.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 2. The file name is 912.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 2. The file name is 912.STensionData.

Run 1, Leg 3, (1/31/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 3 plus supporting data. The plot file name is 913.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3 The cross-wake distance scale is 400m. The plot file name is 913.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3. The cross-wake distance scale is 240m. The plot file name is 913.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 3 The three files plotted are 913.STension400m, 913.FilmPressgraph, and 913.Elasticitygraph.

5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 3. The file name is 913.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 3 The file name is 913.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 3. The file name is 913.STensionData.

Run 1, Leg 4, (1/31/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 4 plus supporting data. The plot file name is 914STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 4 The cross-wake distance scale is 400m. The plot file name is 914.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 4. The cross-wake distance scale is 240m. The plot file name is 914.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 4 The three files plotted are 914.STension400m, 914.FilmPressgraph, and 914.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 4 The file name is 914CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universai elasticity data values for Leg 4 The file name is 914.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 4. The file name is 914.STensionData.

Run 2 (1/31/89): Legs 1, 2, 3

1. Combined plot: Surface tension vs. time for Legs 1, 2, and 3. The three files plotted are 921.STensiontimec, 922.STensiontimec, and 923.STensiontimec.
2. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, and 3. The cross-wake distance scale is 400m. The three files plotted are 921.STension400m, 922.STension400m, and 923.STension400m.
3. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, and 3. The cross-wake distance scale is 240m. The three files plotted are 921.STension240m, 922.STension240m, and 923.STension240m.
4. PMTC tracking plot of STEMS location during Run 2. There is no data file for this plot. It is a hard copy graph from JHUAPL.
5. Tabulated STEMS velocity values (Microsoft Word format) that were obtained from the PMTC tracking plots, listed in 1 minute intervals during Run 2. The name of the MS Word file is Day9Run2.velocity.

Run 2, Leg 1, (1/31/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 1 plus supporting data. The plot file name is 921.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 400m. The plot file name is 921.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 240m. The plot file name is 921.STension240m.

4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 1. The three files plotted are 921.STension400m, 921.FilmPressgraph, and 921.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 1. The file name is 921.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 1. The file name is 921.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 1. The file name is 921.STensionData.

Run 2, Leg 2, (1/31/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 2 plus supporting data. The plot file name is 922.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 400m. The plot file name is 922.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 240m. The plot file name is 922.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 2. The three files plotted are 922.STension400m, 922.FilmPressgraph, and 922.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 2. The file name is 922.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 2. The file name is 922.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 2. The file name is 922.STensionData.

Run 2, Leg 3, (1/31/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 3 plus supporting data. The plot file name is 923.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3 The cross-wake distance scale is 400m. The plot file name is 923.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3. The cross-wake distance scale is 240m. The plot file name is 923.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 3 The three files plotted are 923.STension400m, 923.FilmPressgraph, and 923.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 3. The file name is 923.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 3 The file name is 923.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 3. The file name is 923.STensionData.

Run 3 (1/31/89): Legs 1, 2, 3

1. Combined plot: Surface tension vs. time for Legs 1, 2, and 3. The three files plotted are 931.STensiontimec, 932.STensiontimec, and 933.STensiontimec.
2. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, and 3. The cross-wake distance scale is 400m. The three files plotted are 931.STension400m, 932.STension400m, and 933.STension400m.
3. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, and 3. The cross-wake distance scale is 240m. The three files plotted are 931.STension240m, 932.STension240m, and 933.STension240m.
4. PMTC tracking plot of STEMS location during Run 3. There is no data file for this plot. It is a hard copy graph from JHUAPL.
5. Tabulated STEMS velocity values (Microsoft Word format) that were obtained from the PMTC tracking plots, listed in 1 minute intervals during Run 3. The name of the MS Word file is Day9Run3.velocity.

Run 3, Leg 1, (1/31/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 1 plus supporting data. The plot file name is 931.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 400m. The plot file name is 931.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 240m. The plot file name is 931.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 1. The three files plotted are 931.STension400m, 931.FilmPressgraph, and 931.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 1. The file name is 931.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 1. The file name is 931.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 1. The file name is 931.STensionData.

Run 3, Leg 2, (1/31/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 2 plus supporting data. The plot file name is 932.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 400m. The plot file name is 932.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 240m. The plot file name is 932.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 2. The three files plotted are 932.STension400m, 932.FilmPressgraph, and 932.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 2. The file name is 932.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 2. The file name is 932.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 2. The file name is 932.STensionData.

Run 3, Leg 3, (1/31/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 3 plus supporting data. The plot file name is 933.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3 The cross-wake distance scale is 400m. The plot file name is 933.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3. The cross-wake distance scale is 240m. The plot file name is 933.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 3. The three files plotted are 933.STension400m, 933.FilmPressgraph, and 933.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 3. The file name is 933.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 3. The file name is 933.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 3. The file name is 933.STensionData.

Run 4 (1/31/89): Legs 1, 2, 3

1. Combined plot: Surface tension vs. time for Legs 1, 2, and 3. The three files plotted are 941.STensiontimec, 942.STensiontimec, and 943.STensiontimec.
2. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, and 3. The cross-wake distance scale is 400m. The three files plotted are 941.STension400m, 942.STension400m, and 943.STension400m.
3. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, and 3. The cross-wake distance scale is 240m. The three files plotted are 941.STension240m, 942.STension240m, and 943.STension240m.
4. PMTC tracking plot of STEMS location during Run 4. There is no data file for this plot. It is a hard copy graph from JHUAPL.
5. Tabulated STEMS velocity values (Microsoft Word format) that were obtained from the PMTC tracking plots, listed in 1 minute intervals during Run 4. The name of the MS Word file is Day9Run4.velocity.

Run 4, Leg 1, (1/31/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 1 plus supporting data. The plot file name is 941.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 400m. The plot file name is 941.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 240m. The plot file name is 941.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 1. The three files plotted are 941.STension400m, 941.FilmPressgraph, and 941.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 1. The file name is 941.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 1. The file name is 941.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 1. The file name is 941.STensionData.

Run 4, Leg 2, (1/31/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 2 plus supporting data. The plot file name is 942.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 400m. The plot file name is 942.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 240m. The plot file name is 942.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 2. The three files plotted are 942.STension400m, 942.FilmPressgraph, and 942.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 2. The file name is 942.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 2. The file name is 942.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 2. The file name is 942.STensionData.

Run 4, Leg 3, (1/31/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 3 plus supporting data. The plot file name is 943.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3 The cross-wake distance scale is 400m. The plot file name is 943.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3. The cross-wake distance scale is 240m. The plot file name is 943.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 3 The three files plotted are 943.STension400m, 943.FilmPressgraph, and 943.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 3. The file name is 943.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 3 The file name is 943.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 3. The file name is 943.STensionData.

Day 10 (2/1/89): Runs 1, 2, 3

1. Wake crossing data tables (Microsoft Powerpoint format): Runs 1, 2 and 3. The data are stored in file 2.1.89(1,2,3).

2. Ln-Ln plot of surfactant wake width vs. distance aft of the ship for all of the runs completed during the day. The plot file is wwday10.grf, and the data are stored in [Wake Width (B) Ln-Ln].

3. Surface tension and film pressure vs. area graphs for all the water samples taken during the morning runs. The plot files are SurfTens/area.composite and FilmPress/area.composite.

4. Tabulated listings (Microsoft Word and Cricket Graph spread sheet format) of the potential, surface tension, and film pressure vs. area values for the water samples taken during the morning runs. The Cricket Graph data files are Parea26.24hrs0920am, Parea28.18hrs0745am, Parea29a.18hrs1155am and

Parea29b.18hrs0730am. The MS Word data files are FP26.MSWord, FP28.MSWord, FP29a.MSWord and FP29b.MSWord.

Run 1 (2/1/89): Legs 1, 2, 3

1. Combined plot: Surface tension vs. time for Legs 1, 2, and 3. The three files plotted are 1011.STensiontimec, 1012.STensiontimec, and 1013.STensiontimec.
2. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, and 3. The cross-wake distance scale is 400m. The three files plotted are 1011.STension400m, 1012.STension400m, and 1013.STension400m.
3. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, and 3. The cross-wake distance scale is 240m. The three files plotted are 1011.STension240m, 1012.STension240m, and 1013.STension240m.
4. PMTC tracking plot of STEMS location during Run 1. There is no data file for this plot. It is a hard copy graph from JHUAPL.
5. Tabulated STEMS velocity values (Microsoft Word format) that were obtained from the PMTC tracking plots, listed in 1 minute intervals during Run 1. The name of the MS Word file is Day10Run1.velocity.

Run 1, Leg 1, (2/1/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 1 plus supporting data. The plot file name is 1011.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 400m. The plot file name is 1011.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 240m. The plot file name is 1011.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 1. The three files plotted are 1011.STension400m, 1011.FilmPressgraph, and 1011.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 1. The file name is 1011.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 1. The file name is 1011.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 1. The file name is 1011.STensionData.

Run 1, Leg 2, (2/1/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 2 plus supporting data. The plot file name is 1012.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 400m. The plot file name is 1012 STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 240m. The plot file name is 1012.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 2. The three files plotted are 1012.STension400m. 1012.FilmPressgraph, and 1012.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 2. The file name is 1012.CutElasticity.

6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 2. The file name is 1012 MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 2. The file name is 1012.STensionData.

Run 1, Leg 3, (2/1/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 3 plus supporting data. The plot file name is 1013.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3 The cross-wake distance scale is 400m. The plot file name is 1013.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3. The cross-wake distance scale is 240m. The plot file name is 1013.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 3 The three files plotted are 1013.STension400m, 1013.FilmPressgraph, and 1013.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 3. The file name is 1013.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 3 The file name is 1013.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 3. The file name is 1013.STensionData.

Run 2 (2/1/89): Legs 1, 2, 3

1. Combined plot: Surface tension vs. time for Legs 1, 2, and 3. The three files plotted are 1021.STensiontimec, 1022.STensiontimec, and 1023.STensiontimec.
2. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, and 3. The cross-wake distance scale is 400m. The three files plotted are 1021.STension400m, 1022.STension400m, and 1023.STension400m.
3. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, and 3. The cross-wake distance scale is 240m. The three files plotted are 1021.STension240m, 1022.STension240m, and 1023.STension240m.
4. PMTC tracking plot of STEMS location during Run 2. There is no data file for this plot. It is a hard copy graph from JHUAPL.
5. Tabulated STEMS velocity values (Microsoft Word format) that were obtained from the PMTC tracking plots, listed in 1 minute intervals during Run 2. The name of the MS Word file is Day10Run2.velocity.

Run 2, Leg 1, (2/1/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 1 plus supporting data. The plot file name is 1021.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 400m. The plot file name is 1021.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 240m. The plot file name is 1021.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure and elasticity (real and universal) vs. cross-wake distance for Leg 1. The three files plotted are 1021.STension400m, 1021.FilmPressgraph, and 1021.Elasticitygraph.

5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 1. The file name is 1021.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 1. The file name is 1021.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 1. The file name is 1021.STensionData.

Run 2, Leg 2, (2/1/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 2 plus supporting data. The plot file name is 1022.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 400m. The plot file name is 1022.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 240m. The plot file name is 1022.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 2. The three files plotted are 1022.STension400m, 1022.FilmPressgraph, and 1022.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 2. The file name is 1022.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 2. The file name is 1022.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 2. The file name is 1022.STensionData.

Run 2, Leg 3, (2/1/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 3 plus supporting data. The plot file name is 1023.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3 The cross-wake distance scale is 400m. The plot file name is 1023.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3. The cross-wake distance scale is 240m. The plot file name is 1023.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 3 The three files plotted are 1023.STension400m, 1023.FilmPressgraph, and 623.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 3. The file name is 1023.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 3 The file name is 1023.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 3. The file name is 1023.STensionData.

Run 3 (2/1/89): Legs 1, 2, 3

1. Combined plot: Surface tension vs. time for Legs 1, 2, and 3. The three files plotted are 1031.STensiontimec, 1032.STensiontimec, and 1033.STensiontimec.

2. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, and 3. The cross-wake distance scale is 400m. The three files plotted are 1031.STension400m, 1032.STension400m, and 1033.STension400m.
3. Combined plot: Surface tension vs. cross-wake distance for Legs 1, 2, and 3. The cross-wake distance scale is 240m. The three files plotted are 1031.STension240m, 1032.STension240m, and 1033.STension240m.
4. PMTC tracking plot of STEMS location during Run 3. There is no data file for this plot. It is a hard copy graph from JHUAPL.
5. Tabulated STEMS velocity values (Microsoft Word format) that were obtained from the PMTC tracking plots, listed in 1 minute intervals during Run 3. The name of the MS Word file is Day10Run3.velocity.

Run 3, Leg 1, (2/1/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 1 plus supporting data. The plot file name is 1031.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 400m. The plot file name is 1031.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 1. The cross-wake distance scale is 240m. The plot file name is 1031.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 1. The three files plotted are 1031.STension400m, 1031.FilmPressgraph, and 1031.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 1. The file name is 1031.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 1. The file name is 1031.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 1. The file name is 1031.STensionData.

Run 3, Leg 2, (2/1/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 2 plus supporting data. The plot file name is 1032.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 400m. The plot file name is 1032.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 2. The cross-wake distance scale is 240m. The plot file name is 1032.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 2. The three files plotted are 1032.STension400m, 1032.FilmPressgraph, and 1032.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 2. The file name is 1032.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 2. The file name is 1032.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 2. The file name is 1032.STensionData.

Run 3, Leg 3, (2/1/89)

1. Individual Plot (from complete data file): Surface tension vs. time for Leg 3 plus supporting data. The plot file name is 1033.STensiontime.
2. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3 The cross-wake distance scale is 400m. The plot file name is 1033.STension400m.
3. Individual Plot (from complete data file): Surface tension vs. cross-wake distance for Leg 3. The cross-wake distance scale is 240m. The plot file name is 1033.STension240m.
4. Combined Plot (from abbreviated [shortened] data files): Surface tension, film pressure, and elasticity (real and universal) vs. cross-wake distance for Leg 3. The three files plotted are 1033.STension400m, 1033.FilmPressgraph, and 1033.Elasticitygraph.
5. ASCII data file (Cricket Graph spread sheet format): Abbreviated (shortened) listing of cross-wake distance, surface tension, film pressure, and elasticity (measured [real] and universal [calculated]) data values for Leg 3. The file name is 1033.CutElasticity.
6. MS Word file: Abbreviated listing of cross-wake distance, surface tension, film pressure, and real and universal elasticity data values for Leg 3. The file name is 1033.MSWord.
7. ASCII data file (Cricket Graph spread sheet format): complete listing of all time, STEMS velocity, cross-wake distance, surface tension, and film pressure data values for Leg 3. The file name is 1033.STensionData.

Appendix 7.2. Video Data Base Archive

Appendix 7.2.

The quality of the STEMS video data and ultimately the quality and resolution of the cross-wake surface tension distribution was influenced by a number of different factors. These factors are:

1. Towing speed. The spatial resolution of the technique depends on the towing speed. At a constant oil dropping rate, increasing the towing speed will decrease the spatial resolution.

2. Oil dropping rates. The spatial resolution of the technique depends on the oil dropping rate. At a constant towing speed, increasing the dropping rate will increase the spatial resolution.

3. Sun and video camera angles with respect to the water surface. The visibility of the oils on the water surface was significantly affected by the sun and video camera angles during the wake crossings as the STEMS changed headings.

4. Wind speed and short wave (30 cm - 3 m) amplitude. As the wind speed increased from 5 to 10 m/s, the amplitude of the short waves increased and the resolution of the technique started to degrade until it was no longer possible to see the oils on the surface because of all the splashing, wave breaking and immersion of the needles.

5. Heading of the towing boat relative to the wind direction. For those runs where the wind direction was nearly perpendicular to the towing direction, the towing boat acted as a wind shield (short wave blocker). When the STEMS was on the downwind side of the boat in this shielded region, the resolution was significantly better than when the STEMS was on the upwind side of the towing boat.

6. Visibility of the smoke flares and the duration of the smoke from the flares. The smoke flares were used to visibly locate and mark the wake edges and assist the towing boat operator as he tried to navigate and cross both of the edges during the runs. After the smoke ran out, it became more difficult to assure that the STEMS crossed through both edges of the wake.

7. Visibility and persistence of the foam and surfactant edge bands. Another method that the towing boat operator could use to determine his position relative to the wake was the presence, visibility and persistence of the foam and surfactant edge bands created by the target ship as it crossed in front of the towing boat. The target ships that created foam and surfactant bands that were visually persistent made it easier to locate the wake edges and navigate during the runs.

8. Ambient surfactant slick population. In calmer water conditions where there were a lot of ambient slicks present, the wake edges could merge or combine with these slicks and make an accurate determination of the location of the wake edge difficult to impossible. Long ambient slicks in the vicinity of the surfactant edge bands could also confuse the process further.

9. Contamination of the target vessel wake by the towing ship's wake or the wake of another research vessel. This generally was not a problem except for a couple of crossings.

Table 9 summarizes the quality of the STEMS video data for all of the wake crossing attempted during the ten day Field Test. The various quality assessments used in Table 9 are:

N - Virtually no useful information about the wake can be extracted from the data.

VM - The data is of a very marginal quality. There may be some sporadic information about the wake in the video record, however, a sizable amount of effort will be required to locate and extract that information.

M - The data quality is marginal. There appears to be enough information in the video to extract a fairly detailed cross-wake surface tension distribution, however some extra effort will be required to locate and extract that information at some locations.

E - The data quality is excellent. A detailed cross-wake surface tension structure can be extracted from the video with minimal effort.

Table 9. STEMS video data quality for each crossing

	Run 1	Run 2	Run 3	Run 4
Jan.23, Legs;	1 2 3 4 5 6	1 2 3	1 2 3	1 2 3 4
Data Quality	N N N N N N	VM VM N	VM VM N	N VM N VM
Jan. 24, Legs;	No Data	No Data	No Data	No Data
Jan. 25, Legs;	1 2 3	1 2 3	1 2 3 4	1 2 3
Data Quality	N VM N	N VM N	VM VM N VM	VM N VM
Jan. 26, Legs;	No Data	No Data	No Data	No Data
Jan. 27, Legs;	1 2 3 4	1 2 3	1 2 3 4	No Operations
Data Quality	E E E E	E E E	E E E E	
Jan. 28, Legs;	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
Data Quality	E E E E	E M E M	E M E M	E E E E
Jan. 29, Legs;	1 2 3 4	1 2 3	1 2	1 2
Data Quality	E E E E	E E M	N VM	N VM
Jan. 30, Legs	No Operations	No Operations	No Operations	No Operations
Jan. 31, Legs;	1 2 3 4	1 2 3	1 2 3	1 2 3
Data Quality	E E E E	E E E	E E E	E E E
Feb. 1, Legs	1 2 3	1 2 3	1 2 3	No Operations
Data Quality	E E E	E E E	E E E	

Brief daily summary of the STEMS video data

Day 1, Jan. 23, 1989: The Surface TEnsion Measuring Sled (STEMS) was operated during all four test runs. There were a significant amount of wind induced short waves and whitecaps at the surface which greatly reduced the quality of the measurements during the entire day. Virtually no useful information about the wake can be extracted from the six wake crossings made during the 12 knot run (Run 1). In order to try to minimize the effect of the surface roughness on the spreading oils, the towing speed of the sled was reduced from 1.5 to 0.5 knots. This reduced the number of wake crossings from six to three or four. For runs 2 (25 knots), 3 (18 knots), and 4 (18 knots), some very marginal (VM) data was obtained during six of the wake crossings. The term, very marginal, means that there may be some information about the wake properties in the data; however, it will take a sizable amount of extra effort to determine how valuable the data really is.

Day 2, Jan. 24, 1989: The STEMS could not operate on the second day of the experiment because the winds were too high and the sea was very rough (much whitecapping).

Day 3, Jan. 25, 1989: The STEMS was operated during the four test runs. Wind waves and whitecaps reduced the quality of the measurements. During Run 1, the data was contaminated by an unknown noise source that turned out to be a ground loop set up between the 220 V and 110 V outlets of the generator that was used to supply power to the instrument trailer, STEMS, and video gear. Some very marginal data was obtained during some of the wake crossings. For runs 3 and 4, some very marginal (VM) data was obtained during three of the wake crossings.

Day 4, Jan. 26, 1989: The STEMS could not operate on the fourth day of the experiment because the winds were too high and the sea was very rough (much whitecapping).

Day 5, Jan. 27, 1989: Since the Ops plan called for a Kelvin Wake module, the STEMS was operated during Runs 1, 2, and 3. Excellent data was obtained during all the wake crossings. Distinct, persistent foam and edge bands were observed both visually and with the spreading oils.

Day 6, Jan. 28, 1989: The STEMS was operated during all four Runs. The data was generally good with a few legs in the marginal category because of surface roughness problems. The term marginal means that some extra effort will be required to analyze the video data in order to learn about the wake properties. Distinct foam and edge bands were observed.

Day 7, Jan. 29, 1989: Measurements were obtained during all four test runs. Excellent data was obtained during Runs 1 and 2. As Run 2 progressed, there was a significant increase in the surface wind speed that quickly generated surface roughness and whitecaps. Between Runs 2 and 3, we has a major equipment problem that limited our operations during Runs 3 and 4 to two wake crossings after we temporarily corrected the problem. Because of the surface roughness and high winds, the data during Runs 3 and 4 was marginal at best. Persistent edge and foam bands were observed during the first two runs.

Day 8, Jan. 30, 1989: There were no operations on this day.

Day 9, Jan. 31, 1989: Excellent data was obtained for all the wake crossing with the STEMS during Runs 1, 2, 3 and 4. Persistent edge and foam bands were observed. There were also ambient slicks present that may confuse the data somewhat.

Day 10, Feb. 1, 1989: Excellent data was obtained for the wake crossings with the STEMS during Runs 1, 2, and 3. Run 4 was a Kelvin wake run. Persistent edge foam bands were observed.

The following, Table 10, contains a detailed log and description of the eight STEMS and environment video data tape sets that were recorded during the field experiment. The counter numbers were taken off a Panasonic video recorder, model number NV8950. They indicate the position of the data on the tape. The STEMS video tapes contain the spreading oil histories that were recorded by the video camera mounted on the STEMS as it was being towed across the target ship wakes by the R/V Garnet Banks. These histories were used to obtain all the detailed, cross-wake surface tension distributions presented throughout the paper and in the data notebooks. The environmental data was recorded by a video camera that was mounted on the bridge of the R/V Garnet banks. This camera was positioned so that the STEMS was always in the field of view of the camera.

Table 10. Detailed description of the STEMS video data tapes

		Run 1, Jan. 23, 12 kts. (Start Video Tape 1).
Leg 1 Counter	8:45 - 8:51 590 - 930	Excessive towing speed, wave breaking, high amplitude short waves, needles dipping in water, no useful data.
Leg 2 Counter	8:53 - 8:56 1028 - 1240	Excessive towing speed, wave breaking, high amplitude short waves, needles dipping in water, no useful data.
Leg 3 Counter	8:58 - 9:03 1348 - 1690	Excessive towing speed, wave breaking, high amplitude short waves, needles dipping in water, no useful data.
Leg 4 Counter	9:03 - 9:07 1720 - 1909	Excessive towing speed, wave breaking, high amplitude short waves, needles dipping in water, no useful data.
Leg 5 Counter	9:11 - 9:16:40 1940 - 2230	Excessive towing speed, wave breaking, high amplitude short waves, needles dipping in water, no useful data.
Leg 6 Counter	9:18 - 9:23 2310 - 2550	Some environment data during turns.
		Run 2, Jan. 23, 25 kts.
Leg 1 Counter	9:33 - 9:44 2567 - 3070	Choppy, needles dipped, data marginal, some edge bands may be visible.
Leg 2 Counter	9:46 - 9:53 3180 - 3490	In lee of boat, some usable data.
Leg 3 Counter	9:55 - 10:03 3570 - 3877	Very choppy; hard to see oils because of the wave breaking, chop, dipping needles etc., no useful data.
Leg 4 Counter	10:03 - 10:05 3878 - 3971	Cut short to get into position for the next run.
		Run 3, Jan. 23, 18 kts.
Leg 1 Counter	10:27 - 10:35 3990 - 4250	Choppy, wave breaking, marginal data.
Leg 2 Counter	10:38 - 10:49 4397 - 4750	In lee of boat, marginal usable data.
		Run 4, Jan. 23, 18 kts.
Leg 1 Counter	11:12 - 11:21 4780 - 4995	Choppy, wave breaking, no usable data.
Leg 2 Counter	11:21 - 11:31 5006 - 5240	In lee of boat, no usable data.
Leg 3	11:31 - 11:41	No usable data.

Counter	5240 - 5430	
Leg 4 Counter	11:41 - 11:46 5430 - 5588	Lee of boat, marginal usable data, **(End Video Tape 1).**
		Jan. 24, CGN, Could not run because of rough weather.
		Run 1, Jan. 25, 12 kts, (Begin Video Tape 2).
Leg 1 Counter	8:36 - 8:44 0000 - 0468	Noises on video, poor contrast, no usable data.
Leg 2 Counter	08:48 - 09:00 0480 - 0991	Noise on video due to ground loop in generator, poor contrast, oils barely visible lee side of boat, very marginal data.
Leg 3 Counter	09:02 - 09:06 1002 - 1180	Solved noise problem, oils barely visible, no usable data.
		Run 2, Jan. 25, 25 kts.
Leg 1 Counter	9:28 - 9:34 1208 - 1580	Turbulent wave breaking, choppy, intermittent usable data.
Leg 2 Counter	9:37 - 9:42 1600 - 1900	Poor contrast, lee of boat, very marginal data.
Leg 3 Counter	9:47 - 9:54 1920 - 2270	Scattered data points, choppy wave breaking, intermittent usable data.
		Run 3, Jan. 25, 18 kts.
Leg 1 Counter	10:15 - 10:21 2389 - 2650	Turbulent, wave breaking, some usable data.
Leg 2 Counter	10:24 - 10:27 2662 - 2850	Lee of boat, marginal data.
Leg 3 Counter	10:35 - 10:40 2854 - 3130	Turbulent, wave breaking, intermittent marginal data.
Leg 4 Counter	10:44 - 10:49 3138 - 2366	Lee side, marginal data.
		Run 4, Jan. 25, 18 kts.
Leg 1 Counter	11:08 - 11:16 3450 - 3770	Marginal data.
Leg 2 Counter	11:20 - 11:26 3775 - 4020	Turbulent, wave breaking, scattered data not useful.
Leg 3 Counter	11:30 - 11:37 4025 - 4285	Poor contrast, very marginal data, **(End Video Tape 2).**

REMARKS: Adjusted camera settings and increased the height and angle.

Jan. 26, FFG.
Did not run, sea too rough, too windy.

Jan. 27, FFG, Run 1, 12 kts, (Begin Video Tape 3).

Leg 1 Counter	8:35 - 8:42 0671 - 1176	Possible edge bands, marginal data, surface tension and temporal/ spatial resolution is poor because oils were dripping very slowly.
Leg 2 Counter	8:45 - 8:53 1350 - 1880	Possible edge bands, marginal data, surface tension and temporal/ spatial resolution is poor because oils were dripping very slowly.
Leg 3 Counter	8:56 - 9:03 2060 - 2400	Possible edge bands, marginal data, surface tension and temporal/ spatial resolution is poor because oils were dripping very slowly.
Leg 4 Counter	9:06 - 9:13 2565 - 2870	Possible edge bands, marginal data, surface tension and temporal/ spatial resolution is poor because oils were dripping very slowly.

Run 2, Jan. 27, 25 kts.

Leg 1 Counter	9:26 - 9:35 3000 - 3408	Foam/edge bands, excellent data.
Leg 2 Counter	9:37 - 9:45 3532 - 3830	Foam/edge bands, excellent data.
Leg 3 Counter	9:48 - 9:56 3945 - 4240	Foam/edge bands, second edge band?, excellent data.
Leg 4 Counter	9:58 - 10:02 4325 - 4475	Very quick run to get into position for the next run, data not very . useful

Run 3, Jan. 27, 18 kts.

Leg 1 Counter	10:08 - 10:14 4550 - 4770	Sun angle higher, contrast marginal, foam/edge bands, oils slightly hard to see, data good.
Leg 2 Counter	10:16 - 10:26 4840 - 5200	Contrast better, foam/edge bands, very good data.
Leg 3 Counter	10:29 - 10:37 5201 - 5435	Contrast nominal/sun angle, foam/edge bands, data good.
Leg 4 Counter	10:38 - 10:46 5439 - 5745	Contrast better (sun angle), some wind increase, data very good **(End Video Tape 3).**

Run 4, Jan. 27, Did not participate - KW module.

Jan. 28, DDG, Run 1, 12 kts (Begin Video Tape 4).

Leg 1 Counter	8:39 - 8:48 0000 - 0560	Edge bands?, very good data.

Leg 2 Counter	8:50 - 8:55 0660 - 0951	Edge bands?, very good data.
Leg 3 Counter	8:58 - 9:04 1030 - 1450	Edge bands?, very good data.
Leg 4 Counter	9:07 - 9:17 1573 - 2100	Good data.
		Run 2, Jan. 28, 25 kts
Leg 1 Counter	9:30 - 9:37 2212 - 2490	Lee side, edge bands/foam, very good data.
Leg 2 Counter	9:38 - 9:45 2550 - 2900	Choppy; marginal, useful data.
Leg 3 Counter	9:48 - 9:56 2910 - 3230	Lee of boat, foam/edge bands, very good data.
Leg 4 Counter	9:58 - 10:07 3322 - 3650	Choppy; marginal, useful data.
		Run 3, Jan. 28, 18 kts.
Leg 1 Counter	10:17 - 10:22 3720 - 3910	Lee of boat, foam/edge bands, excellent data.
Leg 2 Counter	10:24 - 10:32 3990 - 4265	Choppy, marginal data.
Leg 3 Counter	10:35 - 10:42 4270 - 4495	Lee of boat, foam/edge bands, excellent data.
Leg 4 Counter	10:44 - 10:53 4540 - 4826	Choppy, marginal data.
		Run 4, Jan. 28, 18 kts.
Leg 1 Counter	11:08 - 11:13 4890 - 5065	Lee of boat, foam/edge bands, excellent data.
Leg 2 Counter	11:17 - 11:25 5100 - 5356	Slight chop, good data.
Leg 3 Counter	11:29 - 11:37 5362 - 5612	Edge bands, lee of boat, excellent data. **(End Video Tape 4).**
Leg 4 Counter	11:40 - 11:48 0000 - 0700	.Slight chop, good data. **(Begin Video Tape 5).**
		Jan. 29, TAO, Run 1, 12 kts.

Leg 1 Counter	8:40 - 8:48 0945 - 1485	Edge/foam bands, excellent data.
Leg 2 Counter	8:50 - 8:57 1590 - 1970	Edge/foam bands, excellent data.
Leg 3 Counter	9:00 - 9:08 2008 - 2395	Slight chop, edge bands, very good data.
Leg 4 Counter	9:10 - 9:17 2406 - 2750	Edge bands, good data.
		Run 2, Jan. 29, 18 kts.
Leg 1 Counter	9:34 - 9:42 2870 - 3188	Contrast getting worse, data good.
Leg 2 Counter	9:43 - 9:58 2316 - 3800	Edge bands, good data.
Leg 3 Counter	9:59 - 10:12 3820 - 4303	The surface is getting significantly rougher w/white caps, contrast lousy, data still usable.
		Run 3, Jan.29, 18 kts.
Leg 1 Counter	10:31 - 10:36 4309 - 4460	Choppy, wave breaking, sporadic data, not usable.
Leg 2 Counter	10:37 - 10:46 4580 - 4840	Very low contrast, will require extensive study to get results.
		REMARKS: Dove the sled under, equipment problems.
		Run 4, Jan. 29, 18 kts.
Leg 1 Counter	11:13 - 11:21 4914 - 5110	Wind has increased significantly, too many holes, choppy wind breaking etc., data not valuable, oils dripping slowly.
Leg 2 Counter	11:23 - 11:30 5145 - 5370	Lee of boat, marginal data. **(End Video Tape 5).**
		Jan. 31, FF, Run 1, 12 kts.
Leg 1 Counter	8:34 - 8:41 0115 - 0685	Edge/foam bands, excellent data. **(Begin Video Tape 6).**
Leg 2 Counter	8:43 - 8:50 0780 - 1245	Edge/foam bands, excellent data.
Leg 3 Counter	8:53 - 9:05 1355 - 2028	Edge/foam bands, excellent data.
Leg 4 Counter	9:07 - 9:19 2060 - 2630	Edge bands, excellent data.

Run 2, Jan. 31, 25 kts.

Leg 1	9:21 - 9:32	Edge/foam bands, excellent data.
Counter	2640 - 3130	
Leg 2	9:35 - 9:47	Edge/foam bands, excellent data.
Counter	3190 - 3693	
Leg 3	9:49 - 10:02	Excellent data.
Counter	3710 - 4185	

.Run 3, Jan. 31. 18 kts.

Leg 1	10:11 - 10:22	Foam/edge bands, slicks, good data (sun angle reduced contrast).
Counter	4330 - 4720	
Leg 2	10:24 - 10:37	Edge bands, slicks, excellent data.
Counter	4740 - 5150	
Leg 3	10:39 - 10:53	Slicks, good data (marginal contrast).
Counter	5170 - 5605	**(End Video Tape 6).**

Run 4, Jan. 31, 20.5 kts.

Leg 1	11:10 - 11:18	Foam/edge bands, excellent data.
Counter	0590 - 1085	**(Begin Video Tape 7).**
Leg 2	11:20 - 11:31	Foam/edge bands, slicks or leftover edge bands, good data (contrast
Counter	1290 - 1895	nominal).
Leg 3	11:32 - 11:42	Edge bands, slicks, excellent data.
Counter	1898 - 2440	

Feb. 1, FF, (Added oil 23, took away 1).

Run 1, Feb. 1, 12 kts.

Leg 1	8:38 - 8:47	Slightly choppy, foam/edge bands, very good data.
Counter	2550 - 2960	
Leg 2	8:49 - 9:01	Lee of boat, foam/edge bands, excellent data.
Counter	2972 - 3460	
Leg 3	9:03 - 9:16	Slight chop, edge bands, good data.
Counter	3475 - 3950	

Run 2, Feb. 1, 25 kts.

Leg 1	9:23 - 9:30	Foam/edge bands, good data.
Counter	3960 - 4198	
Leg 2	9:33 - 9:42	Foam/edge bands, good data.
Counter	4212 - 4534	

Leg 3 Counter	9:44 - 9:58 4535 - 5010	Edge bands, good data. **(End Video Tape 7).**
		Run 3, Feb. 1, 18 kts.
Leg 1 Counter	10:13 - 10:22 0210 - 0887	Foam/edge bands, good data. **(Begin Video Tape 8).**
Leg 2 Counter	10:23 - 10:34 0914 - 1615	Edge bands, slicks, very good data.
Leg 3 Counter	10:36 - 10:50 1654 - 2400	Portions of the Leg may be contaminated when the R/V Sea Tech crossed in front of us through the target ship wake, good data.

Appendix 7.3. Contents of the Supporting Data Index

Appendix 7.3.

The following is a consolidated listing of all the graph and data files that are contained in the five 3.25 inch computer discs. Each of the discs contain the Runs that correspond to one of the five test days that the NRL STEMS was able to obtain high-quality data. Days 5, 6, 7, 9, and 10 correspond to Jan.27, Jan. 28, Jan. 29, Jan. 31, and Feb. 1, 1989, respectively. The files that pertain to individual Runs and Legs (wake crossings) are separated into specific folders on the disc. Individual file names listed in this appendix generally contain descriptions of the contents and type of the file. The majority of the files are coded as follows; [XXYZ.description], where XX is the number of days into the field test (Jan. 23, 1989 is day 1 and Feb 1, 1989 is day 10), Y is the Run module number completed by the Navy Target Ship during the operations on that given day (Runs 1-4), and Z is the number of the wake crossing (or leg) completed by the NRL STEMS during that Run (crossings or legs 1-4). The reader is referred to Appendix 7.1 for a complete description of all the individual files.

Day 5

84 items | 75.2 MB in disk | 22.4 MB available

Name	Size	Kind	Last Modified
5.2	188K	folder	Sat, Jul 11, 1992, 1:12 PM
52.Elasticity	52K	folder	Sat, Jul 11, 1992, 12:04 PM
521.CutElasticity	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 1:30 PM
521.Elasticitygraph	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:16 PM
521.FilmPressgraph	2K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:09 PM
521.STension400m	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 12:59 PM
522.CutElasticity	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 1:55 PM
522.Elasticitygraph	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:14 PM
522.FilmPressgraph	2K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:07 PM
522.STension400m	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 1:00 PM
523.CutElasticity	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 1:33 PM
523.Elasticitygraph	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:12 PM
523.FilmPressgraph	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:05 PM
523.STension400m	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 1:01 PM
52.MSWord	16K	folder	Sat, Jul 11, 1992, 10:06 AM
521.MSWord	4K	Microsoft Word doc...	Sat, Jul 11, 1992, 10:59 AM
522.MSWord	6K	Microsoft Word doc...	Sat, Jul 11, 1992, 10:59 AM
523.MSWord	6K	Microsoft Word doc...	Sat, Jul 11, 1992, 10:58 AM
52.SurfaceTension	120K	folder	Tue, Jul 7, 1992, 1:57 PM
521.STension240m	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 12:54 PM
521.STension400m	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 12:59 PM
521.STensionData	18K	Cricket Graph docu...	Sat, Jul 11, 1992, 1:28 PM
521.STensiontime	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 1:16 PM
521.STensiontimec	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 1:24 PM
522.STension240m	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 12:56 PM
522.STension400m	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 1:00 PM
522.STensionData	20K	Cricket Graph docu...	Tue, Jul 7, 1992, 12:52 PM
522.STensiontime	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 1:14 PM
522.STensiontimec	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 1:20 PM
523.STension240m	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 12:57 PM
523.STension400m	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 1:01 PM
523.STensionData	18K	Cricket Graph docu...	Tue, Jul 7, 1992, 12:52 PM
523.STensiontime	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 1:13 PM
523.STensiontimec	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 1:18 PM
5.3	242K	folder	Sat, Jul 11, 1992, 1:12 PM
53.Elasticity	66K	folder	Tue, Jul 7, 1992, 3:07 PM
531.CutElasticity	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 3:06 PM
531.Elasticitygraph	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 3:19 PM
531.FilmPressgraph	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 3:13 PM
531.STension400m	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:50 PM
532.CutElasticity	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 3:06 PM
532.Elasticitygraph	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 3:18 PM
532.FilmPressgraph	2K	Cricket Graph docu...	Tue, Jul 7, 1992, 3:12 PM
532.STension400m	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:47 PM

Day 5

84 items — 75.2 MB in disk — 22.4 MB available

Name	Size	Kind	Last Modified
533.CutElasticity	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 3:05 PM
533.Elasticitygraph	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 3:17 PM
533.FilmPressgraph	2K	Cricket Graph docu...	Tue, Jul 7, 1992, 3:11 PM
533.STension400m	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:46 PM
534.CutElasticity	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 3:04 PM
534.Elasticitygraph	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 3:15 PM
534.FilmPressgraph	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 3:10 PM
534.STension400m	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:44 PM
53.MS Word	20K	folder	Sat, Jul 11, 1992, 10:14 AM
531.MSWord	6K	Microsoft Word doc...	Sat, Jul 11, 1992, 10:57 AM
532.MSWord	4K	Microsoft Word doc...	Sat, Jul 11, 1992, 10:57 AM
533.MSWord	4K	Microsoft Word doc...	Sat, Jul 11, 1992, 10:57 AM
534.MSWord	6K	Microsoft Word doc...	Sat, Jul 11, 1992, 10:57 AM
53.Surface Tension	156K	folder	Tue, Sep 1, 1992, 9:37 AM
531.STension240m	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:42 PM
531.STension400m	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:50 PM
531.STensionData	12K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:23 PM
531.STensiontime	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:34 PM
531.STensiontimec	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:55 PM
532.STension240m	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:40 PM
532.STension400m	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:47 PM
532.STensionData	22K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:22 PM
532.STensiontime	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:29 PM
532.STensiontimec	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:54 PM
533.STension240m	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:38 PM
533.STension400m	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:46 PM
533.STensionData	16K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:21 PM
533.STensiontime	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:31 PM
533.STensiontimec	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:53 PM
534.STension240m	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:37 PM
534.STension400m	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:44 PM
534.STensionData	20K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:20 PM
534.STensiontime	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:33 PM
534.STensiontimec	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 2:52 PM
Day5.Supportingdata	36K	folder	Tue, Sep 1, 1992, 9:24 AM
1.27.89(2,3)	12K	PowerPoint document	Wed, Jul 22, 1992, 2:24 PM
Day5Run2.velocity	4K	Microsoft Word doc...	Fri, Jul 24, 1992, 1:54 PM
Day5Run3.velocity	4K	Microsoft Word doc...	Fri, Jul 24, 1992, 1:56 PM
Labelsday5.notebook	12K	Microsoft Word doc...	Tue, Jul 21, 1992, 10:42 AM
wwday5.grf	4K	Cricket Graph docu...	Mon, Jul 13, 1992, 8:42 AM

Day 6

165 items | 75.2 MB in disk | 22.4 MB available

Name	Size	Kind	Last Modified
6.1	230K	folder	Sat, Jul 11, 1992, 1:13 PM
61.Elasticity	58K	folder	Mon, Aug 31, 1992, 2:24 PM
611.CutElasticity	2K	Cricket Graph docu…	Fri, Aug 7, 1992, 3:36 PM
611.Elasticitygraph	2K	Cricket Graph docu…	Fri, Aug 7, 1992, 4:42 PM
611.FilmPressgraph	2K	Cricket Graph docu…	Fri, Aug 7, 1992, 4:42 PM
611.STension400	4K	Cricket Graph docu…	Tue, Jul 7, 1992, 3:55 PM
612.CutElasticity	2K	Cricket Graph docu…	Fri, Aug 7, 1992, 3:39 PM
612.Elasticitygraph	2K	Cricket Graph docu…	Fri, Aug 7, 1992, 4:41 PM
612.FilmPressgraph	2K	Cricket Graph docu…	Fri, Aug 7, 1992, 4:39 PM
612.STension400m	4K	Cricket Graph docu…	Tue, Jul 7, 1992, 3:54 PM
613.CutElasticity	4K	Cricket Graph docu…	Fri, Aug 7, 1992, 3:43 PM
613.Elasticitygraph	4K	Cricket Graph docu…	Fri, Aug 7, 1992, 4:47 PM
613.FilmPressgraph	2K	Cricket Graph docu…	Fri, Aug 7, 1992, 4:45 PM
613.STension400m	6K	Cricket Graph docu…	Tue, Jul 7, 1992, 3:52 PM
614.CutElasticity	6K	Cricket Graph docu…	Fri, Aug 7, 1992, 3:50 PM
614.Elasticitygraph	6K	Cricket Graph docu…	Fri, Aug 7, 1992, 4:52 PM
614.FilmPressgraph	4K	Cricket Graph docu…	Fri, Aug 7, 1992, 4:50 PM
614.STension400m	6K	Cricket Graph docu…	Tue, Jul 7, 1992, 3:50 PM
61.MS Word	32K	folder	Sat, Jul 11, 1992, 10:24 AM
611.MSWord	4K	Microsoft Word doc…	Fri, Aug 7, 1992, 5:00 PM
612.MSWord	6K	Microsoft Word doc…	Fri, Aug 7, 1992, 5:02 PM
613.MSWord	8K	Microsoft Word doc…	Fri, Aug 7, 1992, 5:05 PM
614.MSWord	14K	Microsoft Word doc…	Fri, Aug 7, 1992, 5:11 PM
61.SurfaceTension	140K	folder	Tue, Jul 7, 1992, 4:17 PM
611.STension240m	4K	Cricket Graph docu…	Tue, Jul 7, 1992, 3:47 PM
611.STension400m	4K	Cricket Graph docu…	Tue, Jul 7, 1992, 3:55 PM
611.STensionData	10K	Cricket Graph docu…	Tue, Jul 7, 1992, 3:39 PM
611.STensiontime	4K	Cricket Graph docu…	Tue, Jul 7, 1992, 4:06 PM
611.STensiontimec	4K	Cricket Graph docu…	Tue, Jul 7, 1992, 4:10 PM
612.STension240m	4K	Cricket Graph docu…	Tue, Jul 7, 1992, 3:46 PM
612.STension400m	4K	Cricket Graph docu…	Tue, Jul 7, 1992, 3:54 PM
612.STensionData	12K	Cricket Graph docu…	Tue, Jul 7, 1992, 3:38 PM
612.STensiontime	4K	Cricket Graph docu…	Tue, Jul 7, 1992, 4:05 PM
612.STensiontimec	4K	Cricket Graph docu…	Tue, Jul 7, 1992, 4:09 PM
613.STension240m	6K	Cricket Graph docu…	Tue, Jul 7, 1992, 3:44 PM
613.STension400m	6K	Cricket Graph docu…	Tue, Jul 7, 1992, 3:52 PM
613.STensionData	16K	Cricket Graph docu…	Tue, Jul 7, 1992, 3:38 PM
613.STensiontime	6K	Cricket Graph docu…	Tue, Jul 7, 1992, 4:03 PM
613.STensiontimec	4K	Cricket Graph docu…	Tue, Jul 7, 1992, 4:08 PM
614.STension240m	6K	Cricket Graph docu…	Tue, Jul 7, 1992, 3:42 PM
614.STension400m	6K	Cricket Graph docu…	Tue, Jul 7, 1992, 3:50 PM
614.STensionData	24K	Cricket Graph docu…	Tue, Jul 7, 1992, 3:33 PM
614.STensiontime	6K	Cricket Graph docu…	Tue, Jul 7, 1992, 4:02 PM
614.STensiontimec	6K	Cricket Graph docu…	Tue, Jul 7, 1992, 4:07 PM

1

Day 6

165 items | 75.2 MB in disk | 22.4 MB available

Name	Size	Kind	Last Modified
6.2	160K	folder	Wed, Jul 29, 1992, 11:42 AM
62.Elasticity	42K	folder	Fri, Aug 7, 1992, 5:32 PM
621.CutElasticity	4K	Cricket Graph docu...	Fri, Aug 7, 1992, 3:56 PM
621.Elasticitygraph	4K	Cricket Graph docu...	Fri, Aug 7, 1992, 5:18 PM
621.FilmPressgraph	2K	Cricket Graph docu...	Fri, Aug 7, 1992, 5:16 PM
621.STension400m	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 5:04 PM
622.CutElasticity	4K	Cricket Graph docu...	Fri, Aug 7, 1992, 4:01 PM
622.Elasticitygraph	4K	Cricket Graph docu...	Fri, Aug 7, 1992, 5:26 PM
622.FilmPressgraph	2K	Cricket Graph docu...	Fri, Aug 7, 1992, 5:23 PM
622.STension400m	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 5:02 PM
623.CutElasticity	4K	Cricket Graph docu...	Fri, Aug 7, 1992, 4:05 PM
623.Elasticitygraph	4K	Cricket Graph docu...	Fri, Aug 7, 1992, 5:32 PM
623.FilmPressgraph	2K	Cricket Graph docu...	Fri, Aug 7, 1992, 5:30 PM
623.STension400m	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 4:56 PM
62.MS Word	22K	folder	Fri, Aug 7, 1992, 5:13 PM
621.MSWord	8K	Microsoft Word doc...	Fri, Aug 7, 1992, 5:34 PM
622.MSWord	6K	Microsoft Word doc...	Fri, Aug 7, 1992, 5:35 PM
623.MSWord	8K	Microsoft Word doc...	Fri, Aug 7, 1992, 5:36 PM
62.SurfaceTension	96K	folder	Tue, Jul 7, 1992, 5:14 PM
621.STension240m	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 4:54 PM
621.STension400m	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 5:04 PM
621.STensionData	14K	Cricket Graph docu...	Tue, Jul 7, 1992, 4:49 PM
621.STensiontime	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 5:10 PM
621.STensiontimec	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 5:14 PM
622.STension240m	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 4:52 PM
622.STension400m	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 5:02 PM
622.STensionData	16K	Cricket Graph docu...	Tue, Jul 7, 1992, 4:47 PM
622.STensiontime	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 5:09 PM
622.STensiontimec	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 5:13 PM
623.STension240m	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 4:50 PM
623.STension400m	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 4:56 PM
623.STensionData	16K	Cricket Graph docu...	Tue, Jul 7, 1992, 4:47 PM
623.STensiontime	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 5:07 PM
623.STensiontimec	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 5:12 PM
6.3	252K	folder	Sat, Jul 11, 1992, 1:13 PM
63.Elasticity	72K	folder	Wed, Jul 8, 1992, 8:23 AM
631.CutElasticity	4K	Cricket Graph docu...	Thu, May 28, 1992, 6:41 AM
631.Elasticitygraph	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:39 AM
631.FilmPressgraph	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:32 AM
631.STension400m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:04 AM
632.CutElasticity	6K	Cricket Graph docu...	Thu, May 28, 1992, 6:38 AM
632.Elasticitygraph	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:38 AM
632.FilmPressgraph	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:31 AM
632.STension400m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:04 AM

165 items	75.2 MB in disk		22.4 MB available

Name	Size	Kind	Last Modified
633.CutElasticity	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:25 AM
633.Elasticitygraph	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:36 AM
633.FilmPressgraph	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:30 AM
633.STension400m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:01 AM
634.CutElasticity	2K	Cricket Graph docu...	Thu, May 28, 1992, 6:34 AM
634.Elasticitygraph	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:34 AM
634.FilmPressgraph	2K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:29 AM
634.STension400m	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 7:59 AM
▽ 63.MS Word	22K	folder	Sat, Jul 11, 1992, 10:46 AM
631.MSWord	6K	Microsoft Word doc...	Sat, Jul 11, 1992, 10:45 AM
632.MSWord	6K	Microsoft Word doc...	Sat, Jul 11, 1992, 10:46 AM
633.MSWord	6K	Microsoft Word doc...	Sat, Jul 11, 1992, 10:42 AM
634.MSWord	4K	Microsoft Word doc...	Sat, Jul 11, 1992, 10:44 AM
▽ 63.SurfaceTension	158K	folder	Wed, Jul 8, 1992, 8:17 AM
631.STension240m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 7:57 AM
631.STension400m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:04 AM
631.STensionData	14K	Cricket Graph docu...	Wed, Jul 8, 1992, 7:50 AM
631.STensiontime	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:11 AM
631.STensiontimec	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:16 AM
632.STension240m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 7:56 AM
632.STension400m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:04 AM
632.STensionData	18K	Cricket Graph docu...	Wed, Jul 8, 1992, 7:48 AM
632.STensiontime	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:10 AM
632.STensiontimec	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:15 AM
633.STension240m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 7:54 AM
633.STension400m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:01 AM
633.STensionData	18K	Cricket Graph docu...	Wed, Jul 8, 1992, 7:47 AM
633.STensiontime	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:08 AM
633.STensiontimec	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:14 AM
634.STension240m	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 7:52 AM
634.STension400m	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 7:59 AM
634.STensionData	20K	Cricket Graph docu...	Wed, Jul 8, 1992, 7:47 AM
634.STensiontime	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:07 AM
634.STensiontimec	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:13 AM
▽ 6.4	200K	folder	Sat, Jul 11, 1992, 1:13 PM
▽ 64.Elasticity	52K	folder	Wed, Jul 8, 1992, 9:41 AM
641.CutElasticity	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 9:41 AM
641.Elasticitygraph	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 9:49 AM
641.FilmPressgraph	2K	Cricket Graph docu...	Wed, Jul 8, 1992, 9:45 AM
641.STension400m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 9:04 AM
642.CutElasticity	4K	Cricket Graph docu...	Thu, May 28, 1992, 6:48 AM
642.Elasticitygraph	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 9:51 AM
642.FilmPressgraph	2K	Cricket Graph docu...	Wed, Jul 8, 1992, 9:44 AM
642.STension400m	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 9:02 AM

165 items	75.2 MB in disk	22.4 MB available	
Name	Size	Kind	Last Modified
643.CutElasticity	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 9:40 AM
643.Elasticitygraph	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 9:50 AM
643.FilmPressgraph	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 9:43 AM
643.STension400m	8K	Cricket Graph docu...	Wed, Jul 8, 1992, 9:01 AM
64.MS Word	16K	folder	Sat, Jul 11, 1992, 10:52 AM
641.MSWord	6K	Microsoft Word doc...	Sat, Jul 11, 1992, 10:48 AM
642.MSWord	4K	Microsoft Word doc...	Sat, Jul 11, 1992, 10:49 AM
643.MSWord	6K	Microsoft Word doc...	Sat, Jul 11, 1992, 10:50 AM
64.SurfaceTension	132K	folder	Tue, Sep 1, 1992, 10:30 AM
641.STension240m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:59 AM
641.STension400m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 9:04 AM
641.STensionData	18K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:52 AM
641.STensiontime	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 9:20 AM
641.STensiontimec	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 9:25 AM
642.STension240m	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:57 AM
642.STension400m	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 9:02 AM
642.STensionData	20K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:51 AM
642.STensiontime	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 9:18 AM
642.STensiontimec	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 9:24 AM
643.STension240m	8K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:55 AM
643.STension400m	8K	Cricket Graph docu...	Wed, Jul 8, 1992, 9:01 AM
643.STensionData	22K	Cricket Graph docu...	Wed, Jul 8, 1992, 8:51 AM
643.STensiontime	8K	Cricket Graph docu...	Wed, Jul 8, 1992, 9:08 AM
643.STensiontimec	8K	Cricket Graph docu...	Wed, Jul 8, 1992, 9:23 AM
Day6.Supportingdata	58K	folder	Mon, Aug 31, 1992, 2:21 PM
1.28.89(1,3)	14K	PowerPoint document	Fri, Aug 14, 1992, 1:58 PM
1.28.89(2,4)	10K	PowerPoint document	Fri, Aug 14, 1992, 2:00 PM
Day6Run1.velocity	4K	Microsoft Word doc...	Fri, Aug 14, 1992, 2:01 PM
Day6Run2.velocity	4K	Microsoft Word doc...	Fri, Aug 14, 1992, 2:18 PM
Day6Run3.velocity	4K	Microsoft Word doc...	Fri, Aug 14, 1992, 2:19 PM
Day6Run4.velocity	4K	Microsoft Word doc...	Fri, Aug 14, 1992, 2:21 PM
Labelsday6.notebook	14K	Microsoft Word doc...	Tue, Jul 21, 1992, 10:45 AM
wwday6.grf	4K	Cricket Graph docu...	Mon, Jul 13, 1992, 9:46 AM

Day 7

84 items — 75.2 MB in disk — 22.4 MB available

Name	Size	Kind	Last Modified
7.1	204K	folder	Mon, Aug 10, 1992, 11:27 AM
71.Elasticity	64K	folder	Wed, Jul 8, 1992, 11:30 AM
711.CutElasticity	4K	Cricket Graph docu...	Tue, Jun 2, 1992, 10:24 AM
711.Elasticitygraph	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:39 AM
711.FilmPressgraph	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:34 AM
711.STension400m	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:12 AM
712.CutElasticity	2K	Cricket Graph docu...	Tue, Jun 2, 1992, 10:24 AM
712.Elasticitygraph	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:38 AM
712.FilmPressgraph	2K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:33 AM
712.STension400m	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:11 AM
713.CutElasticity	4K	Cricket Graph docu...	Tue, Jun 2, 1992, 10:23 AM
713.Elasticitygraph	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:37 AM
713.FilmPressgraph	2K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:33 AM
713.STension400m	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:09 AM
714.CutElasticity	6K	Cricket Graph docu...	Tue, Jun 2, 1992, 10:23 AM
714.Elasticitygraph	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:37 AM
714.FilmPressgraph	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:32 AM
714.STension400m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:06 AM
71.MS Word	20K	folder	Mon, Aug 10, 1992, 11:45 AM
711.MSWord	6K	Microsoft Word doc...	Mon, Aug 10, 1992, 10:45 AM
712.MSWord	4K	Microsoft Word doc...	Sat, Jul 11, 1992, 11:04 AM
713.MSWord	4K	Microsoft Word doc...	Mon, Aug 10, 1992, 11:28 AM
714.MSWord	6K	Microsoft Word doc...	Mon, Aug 10, 1992, 11:45 AM
71.SurfaceTension	120K	folder	Wed, Jul 8, 1992, 11:30 AM
711.STension240m	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:04 AM
711.STension400m	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:12 AM
711.STensionData	12K	Cricket Graph docu...	Wed, Jul 8, 1992, 10:50 AM
711.STensiontime	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:19 AM
711.STensiontimec	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:23 AM
712.STension240m	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:05 AM
712.STension400m	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:11 AM
712.STensionData	10K	Cricket Graph docu...	Wed, Jul 8, 1992, 10:49 AM
712.STensiontime	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:18 AM
712.STensiontimec	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:22 AM
713.STension240m	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:00 AM
713.STension400m	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:09 AM
713.STensionData	10K	Cricket Graph docu...	Wed, Jul 8, 1992, 10:39 AM
713.STensiontime	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:16 AM
713.STensiontimec	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:21 AM
714.STension240m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 10:59 AM
714.STension400m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:06 AM
714.STensionData	16K	Cricket Graph docu...	Wed, Jul 8, 1992, 10:39 AM
714.STensiontime	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:14 AM
714.STensiontimec	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 11:20 AM

1

Day 7

84 items | 75.2 MB in disk | 22.4 MB available

Name	Size	Kind	Last Modified
7.2	232K	folder	Sat, Jul 11, 1992, 1:14 PM
72.Elasticity	70K	folder	Wed, Jul 8, 1992, 1:28 PM
721.CutElasticity	6K	Cricket Graph docu...	Tue, Jun 2, 1992, 10:22 AM
721.Elasticitygraph	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:36 PM
721.FilmPressgraph	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:31 PM
721.STension400m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:09 PM
722.CutElasticity	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:29 PM
722.Elasticitygraph	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:35 PM
722.FilmPressgraph	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:30 PM
722.STension400m	8K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:13 PM
723.CutELasticity	8K	Cricket Graph docu...	Tue, Jun 2, 1992, 10:21 AM
723.Elasticitygraph	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:33 PM
723.FilmPressgraph	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:30 PM
723.STension400m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:11 PM
72.MS Word	22K	folder	Mon, Aug 10, 1992, 4:25 PM
721.MSWord	6K	Microsoft Word doc...	Sat, Jul 11, 1992, 11:09 AM
722.MSWord	8K	Microsoft Word doc...	Mon, Aug 10, 1992, 12:24 PM
723.MSWord	8K	Microsoft Word doc...	Mon, Aug 10, 1992, 4:25 PM
72.SurfaceTension	140K	folder	Wed, Jul 8, 1992, 1:28 PM
721.STension240m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:06 PM
721.STension400m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:09 PM
721.STensionData	16K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:01 PM
721.STensiontime	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:18 PM
721.STensiontimec	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:21 PM
722.STension240m	8K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:05 PM
722.STension400m	8K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:13 PM
722.STensionData	26K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:00 PM
722.STensiontime	8K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:17 PM
722.STensiontimec	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:20 PM
723.STension240m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:03 PM
723.STension400m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:11 PM
723.STensionData	20K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:00 PM
723.STensiontime	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:14 PM
723.STensiontimec	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:19 PM
Day7.Supportingdata	40K	folder	Tue, Sep 1, 1992, 9:26 AM
1.29.89(1,2)	12K	PowerPoint document	Mon, Aug 10, 1992, 10:32 AM
Day7Run1.velocity	4K	Microsoft Word doc...	Mon, Aug 10, 1992, 10:37 AM
Day7Run2.velocity	4K	Microsoft Word doc...	Mon, Aug 10, 1992, 11:54 AM
Labelsday7.notebook	16K	Microsoft Word doc...	Tue, Jul 21, 1992, 10:47 AM
wwday7.grf	4K	Cricket Graph docu...	Mon, Jul 13, 1992, 8:49 AM

2

Day 9

155 items | 75.2 MB in disk | 22.4 MB available

Name	Size	Kind	Last Modified
9.1	242K	folder	Sat, Jul 11, 1992, 1:14 PM
91.Elasticity	68K	folder	Fri, Aug 7, 1992, 5:49 PM
911.CutElasticity	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 3:18 PM
911.Elasticitygraph	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 3:30 PM
911.FilmPressgraph	2K	Cricket Graph docu...	Wed, Jul 8, 1992, 3:23 PM
911.STension400m	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:56 PM
912.CutElasticity	4K	Cricket Graph docu...	Fri, Aug 7, 1992, 4:15 PM
912.Elasticitygraph	4K	Cricket Graph docu...	Fri, Aug 7, 1992, 5:44 PM
912.FilmPressgraph	4K	Cricket Graph docu...	Fri, Aug 7, 1992, 5:42 PM
912.STension400m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:55 PM
913.CutElasticity	6K	Cricket Graph docu...	Thu, Jun 4, 1992, 6:27 AM
913.Elasticitygraph	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 3:28 PM
913.FilmPressgraph	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 3:24 PM
913.STension400m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:53 PM
914.CutElasticity	4K	Cricket Graph docu...	Fri, Aug 7, 1992, 4:19 PM
914.Elasticitygraph	4K	Cricket Graph docu...	Fri, Aug 7, 1992, 5:49 PM
914.FilmPressgraph	2K	Cricket Graph docu...	Fri, Aug 7, 1992, 5:47 PM
914.STension400m	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:57 PM
91.MS word	26K	folder	Mon, Aug 10, 1992, 5:14 PM
911.MSWord	4K	Microsoft Word doc...	Mon, Aug 10, 1992, 5:14 PM
912.MSWord	10K	Microsoft Word doc...	Fri, Aug 7, 1992, 5:45 PM
913.MSWord	6K	Microsoft Word doc...	Sat, Jul 11, 1992, 11:17 AM
914.MSWord	6K	Microsoft Word doc...	Fri, Aug 7, 1992, 5:50 PM
91.SurfaceTension	148K	folder	Wed, Jul 8, 1992, 3:16 PM
911.STension240m	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:51 PM
911.STension400m	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:56 PM
911.STensionData	16K	Cricket Graph docu...	Mon, Aug 10, 1992, 4:53 PM
911.STensiontime	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 3:00 PM
911.STensiontimec	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 3:04 PM
912.STension240m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:49 PM
912.STension400m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:55 PM
912.STensionData	16K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:43 PM
912.STensiontime	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 2:59 PM
912.STensiontimec	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 3:03 PM
913.STension240m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:47 PM
913.STension400m	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:53 PM
913.STensionData	20K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:42 PM
913.STensiontime	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 2:58 PM
913.STensiontimec	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 3:02 PM
914.STension240m	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:46 PM
914.STension400m	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:57 PM
914.STensionData	16K	Cricket Graph docu...	Wed, Jul 8, 1992, 1:42 PM
914.STensiontime	6K	Cricket Graph docu...	Wed, Jul 8, 1992, 2:57 PM
914.STensiontimec	4K	Cricket Graph docu...	Wed, Jul 8, 1992, 3:01 PM

1

155 items		75.2 MB in disk	22.4 MB available
Name	Size	Kind	Last Modified
9.2	214K	folder	Sat, Jul 11, 1992, 1:14 PM
92. MS Word	18K	folder	Sat, Jul 11, 1992, 11:21 AM
921.MSWord	6K	Microsoft Word doc...	Sat, Jul 11, 1992, 11:19 AM
922.MSWord	6K	Microsoft Word doc...	Sat, Jul 11, 1992, 11:20 AM
923.MSWord	6K	Microsoft Word doc...	Sat, Jul 11, 1992, 11:21 AM
92.Elasticity	56K	folder	Thu, Jul 9, 1992, 9:31 AM
921.CutElasticity	4K	Cricket Graph docu...	Thu, Jul 9, 1992, 9:34 AM
921.Elasticitygraph	4K	Cricket Graph docu...	Thu, Jul 9, 1992, 9:41 AM
921.FilmPressgraph	2K	Cricket Graph docu...	Thu, Jul 9, 1992, 9:37 AM
921.STension400m	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 8:46 AM
922.CutElasticity	4K	Cricket Graph docu...	Thu, Jul 9, 1992, 9:33 AM
922.Elasticitygraph	4K	Cricket Graph docu...	Thu, Jul 9, 1992, 9:42 AM
922.FilmPressgraph	4K	Cricket Graph docu...	Thu, Jul 9, 1992, 9:38 AM
922.STension400m	8K	Cricket Graph docu...	Thu, Jul 9, 1992, 8:45 AM
923.CutElasticity	6K	Cricket Graph docu...	Thu, Jun 4, 1992, 6:33 AM
923.Elasticitygraph	4K	Cricket Graph docu...	Thu, Jul 9, 1992, 9:43 AM
923.FilmPressgraph	4K	Cricket Graph docu...	Thu, Jul 9, 1992, 9:39 AM
923.STension400m	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 8:43 AM
92.SurfaceTension	140K	folder	Tue, Sep 1, 1992, 10:43 AM
921.STension240m	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 8:35 AM
921.STension400m	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 8:46 AM
921.STensionData	18K	Cricket Graph docu...	Thu, Jul 9, 1992, 8:31 AM
921.STensiontime	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 9:25 AM
921.STensiontimec	4K	Cricket Graph docu...	Thu, Jul 9, 1992, 9:24 AM
922.STension240m	8K	Cricket Graph docu...	Thu, Jul 9, 1992, 8:40 AM
922.STension400m	8K	Cricket Graph docu...	Thu, Jul 9, 1992, 8:45 AM
922.STensionData	26K	Cricket Graph docu...	Thu, Jul 9, 1992, 8:30 AM
922.STensiontime	8K	Cricket Graph docu...	Thu, Jul 9, 1992, 9:25 AM
922.STensiontimec	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 9:23 AM
923.STension240m	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 8:38 AM
923.STension400m	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 8:43 AM
923.STensionData	20K	Cricket Graph docu...	Thu, Jul 9, 1992, 8:30 AM
923.STensiontime	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 9:25 AM
923.STensiontimec	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 9:21 AM
9.3	210K	folder	Sat, Jul 11, 1992, 1:14 PM
93.Elasticity	52K	folder	Thu, Jul 9, 1992, 2:00 PM
931.CutElasticity	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 2:03 PM
931.Elasticitygraph	4K	Cricket Graph docu...	Thu, Jul 9, 1992, 2:13 PM
931.FilmPressgraph	4K	Cricket Graph docu...	Thu, Jul 9, 1992, 2:08 PM
931.STension400m	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 10:22 AM
932.CutElasticity	4K	Cricket Graph docu...	Thu, Jul 9, 1992, 2:02 PM
932.Elasticitygraph	4K	Cricket Graph docu...	Thu, Jul 9, 1992, 2:12 PM
932.FilmPressgraph	2K	Cricket Graph docu...	Thu, Jul 9, 1992, 2:08 PM
932.STension400m	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 10:23 AM

Day 9

155 items | 75.2 MB in disk | 22.4 MB available

Name	Size	Kind	Last Modified
933.CutElasticity	4K	Cricket Graph docu...	Thu, Jul 9, 1992, 2:02 PM
933.Elasticitygraph	4K	Cricket Graph docu...	Thu, Jul 9, 1992, 2:10 PM
933.FilmPressgraph	2K	Cricket Graph docu...	Thu, Jul 9, 1992, 2:08 PM
933.STension400m	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 10:24 AM
93.MS Word	16K	folder	Sat, Jul 11, 1992, 11:25 AM
931.MSWord	6K	Microsoft Word doc...	Sat, Jul 11, 1992, 11:23 AM
932.MSWord	4K	Microsoft Word doc...	Sat, Jul 11, 1992, 11:24 AM
933.MSWord	6K	Microsoft Word doc...	Sat, Jul 11, 1992, 11:25 AM
93.SurfaceTension	142K	folder	Thu, Jul 9, 1992, 11:01 AM
931.STension240m	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 10:16 AM
931.STension400m	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 10:22 AM
931.STensionData	26K	Cricket Graph docu...	Thu, Jul 9, 1992, 9:54 AM
931.STensiontime	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 10:55 AM
931.STensiontimec	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 11:00 AM
932.STension240m	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 10:18 AM
932.STension400m	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 10:23 AM
932.STensionData	24K	Cricket Graph docu...	Thu, Jul 9, 1992, 10:05 AM
932.STensiontime	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 10:44 AM
932.STensiontimec	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 10:59 AM
933.STension240m	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 10:20 AM
933.STension400m	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 10:24 AM
933.STensionData	20K	Cricket Graph docu...	Thu, Jul 9, 1992, 9:59 AM
933.STensiontime	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 10:33 AM
933.STensiontimec	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 10:58 AM
9.4	200K	folder	Sat, Jul 11, 1992, 1:14 PM
94.Elasticity	48K	folder	Thu, Jul 9, 1992, 5:02 PM
941.CutElasticity	4K	Cricket Graph docu...	Thu, Jul 9, 1992, 2:37 PM
941.Elasticitygraph	4K	Cricket Graph docu...	Thu, Jul 9, 1992, 4:34 PM
941.FilmPressgraph	2K	Cricket Graph docu...	Thu, Jul 9, 1992, 4:30 PM
941.STension400m	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 3:51 PM
942.CutElasticity	4K	Cricket Graph docu...	Thu, Jul 9, 1992, 2:40 PM
942.Elasticitygraph	4K	Cricket Graph docu...	Thu, Jul 9, 1992, 4:51 PM
942.FilmPressgraph	2K	Cricket Graph docu...	Thu, Jul 9, 1992, 4:48 PM
942.STension400m	8K	Cricket Graph docu...	Thu, Jul 9, 1992, 3:50 PM
943.CutElasticity	2K	Cricket Graph docu...	Thu, Jul 9, 1992, 2:44 PM
943.Elasticitygraph	4K	Cricket Graph docu...	Thu, Jul 9, 1992, 5:02 PM
943.filmPressgraph	2K	Cricket Graph docu...	Thu, Jul 9, 1992, 4:59 PM
943.STension400m	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 3:48 PM
94.MS Word	14K	folder	Sat, Jul 11, 1992, 11:30 AM
941.MSWord	4K	Microsoft Word doc...	Sat, Jul 11, 1992, 11:27 AM
942.MSWord	6K	Microsoft Word doc...	Sat, Jul 11, 1992, 11:30 AM
943.MSWord	4K	Microsoft Word doc...	Sat, Jul 11, 1992, 11:30 AM
94.SurfaceTension	138K	folder	Thu, Jul 9, 1992, 4:25 PM
941.STension240m	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 3:46 PM

Day 9

155 items		75.2 MB in disk	22.4 MB available
Name	**Size**	**Kind**	**Last Modified**
941.STension400m	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 3:51 PM
941.STensionData	16K	Cricket Graph docu...	Thu, Jul 9, 1992, 3:42 PM
941.STensiontime	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 4:19 PM
941.STensiontimec	4K	Cricket Graph docu...	Thu, Jul 9, 1992, 4:22 PM
942.STension240m	8K	Cricket Graph docu...	Thu, Jul 9, 1992, 3:44 PM
942.STension400m	8K	Cricket Graph docu...	Thu, Jul 9, 1992, 3:50 PM
942.STensionData	26K	Cricket Graph docu...	Thu, Jul 9, 1992, 3:41 PM
942.STensiontime	8K	Cricket Graph docu...	Thu, Jul 9, 1992, 4:12 PM
942.STensiontimec	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 4:24 PM
943.STension240m	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 3:43 PM
943.STension400m	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 3:48 PM
943.STensionData	20K	Cricket Graph docu...	Thu, Jul 9, 1992, 3:40 PM
943.STensiontime	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 3:59 PM
943.STensiontimec	6K	Cricket Graph docu...	Thu, Jul 9, 1992, 4:23 PM
Day9.Supportingdata	68K	folder	Tue, Sep 1, 1992, 9:28 AM
1.31.89(1,3)	12K	PowerPoint document	Mon, Aug 10, 1992, 5:03 PM
1.31.89(2,4)	10K	PowerPoint document	Tue, May 19, 1992, 2:43 PM
Day9Run1.velocity	4K	Microsoft Word doc...	Mon, Aug 10, 1992, 5:09 PM
Day9Run2.velocity	4K	Microsoft Word doc...	Tue, Aug 11, 1992, 7:34 AM
Day9Run3.velocity	4K	Microsoft Word doc...	Fri, Aug 14, 1992, 3:40 PM
Day9Run4.velocity	4K	Microsoft Word doc...	Thu, Aug 13, 1992, 10:34 AM
Labelsday9.notebook	26K	Microsoft Word doc...	Tue, Jul 21, 1992, 10:50 AM
wwday9.grf	4K	Cricket Graph docu...	Mon, Jul 13, 1992, 9:02 AM

4

Day 10

109 items | 75.4 MB in disk | 22.2 MB available

Name	Size	Kind	Last Modified
10.1	198K	folder	Fri, Aug 7, 1992, 5:20 PM
101.Elasticity	54K	folder	Sat, Jul 11, 1992, 12:33 PM
1011.CutElasticity	4K	Cricket Graph docu...	Fri, Jun 5, 1992, 9:57 AM
1011.Elasticitygraph	4K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:28 PM
1011.FilmPressgraph	2K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:29 PM
1011.STension400m	4K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:32 PM
1012.CutElasticity	4K	Cricket Graph docu...	Mon, Jul 6, 1992, 8:54 AM
1012.Elasticitygraph	4K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:28 PM
1012.FilmPressgraph	4K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:29 PM
1012.STension400m	6K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:31 PM
1013.CutElasticity	6K	Cricket Graph docu...	Mon, Jul 6, 1992, 8:54 AM
1013.Elasticitygraph	6K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:28 PM
1013.FilmPressgraph	4K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:29 PM
1013.STension400m	6K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:31 PM
101.MS Word	18K	folder	Wed, Aug 12, 1992, 9:13 AM
1011.MSWord	4K	Microsoft Word doc...	Wed, Aug 12, 1992, 9:13 AM
1012.MSWord	6K	Microsoft Word doc...	Sat, Jul 11, 1992, 11:39 AM
1013.MSWord	8K	Microsoft Word doc...	Sat, Jul 11, 1992, 11:40 AM
101.SurfaceTension	126K	folder	Sat, Jul 11, 1992, 12:34 PM
1011.STension240m	4K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:37 PM
1011.STension400m	4K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:32 PM
1011.STensionData	16K	Cricket Graph docu...	Thu, Jul 2, 1992, 2:12 PM
1011.STensiontime	4K	Cricket Graph docu...	Sat, Jul 11, 1992, 1:00 PM
1011.STensiontimec	4K	Cricket Graph docu...	Sat, Jul 11, 1992, 1:01 PM
1012.STension240m	6K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:36 PM
1012.STension400m	6K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:31 PM
1012.STensionData	22K	Cricket Graph docu...	Thu, Jul 2, 1992, 2:16 PM
1012.STensiontime	6K	Cricket Graph docu...	Sat, Jul 11, 1992, 1:00 PM
1012.STensiontimec	4K	Cricket Graph docu...	Sat, Jul 11, 1992, 1:01 PM
1013.STension240m	6K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:36 PM
1013.STension400m	6K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:31 PM
1013.STensionData	26K	Cricket Graph docu...	Thu, Jul 2, 1992, 2:20 PM
1013.STensiontime	6K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:59 PM
1013.STensiontimec	6K	Cricket Graph docu...	Sat, Jul 11, 1992, 1:00 PM
10.2	178K	folder	Sat, Jul 11, 1992, 1:14 PM
102.Elasticity	50K	folder	Sat, Jul 11, 1992, 12:05 PM
1021.CutElasticity	4K	Cricket Graph docu...	Fri, Jun 5, 1992, 10:01 AM
1021.Elasticitygraph	4K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:11 PM
1021.FilmPressgraph	2K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:09 PM
1021.STension400m	4K	Cricket Graph docu...	Mon, Jul 6, 1992, 10:30 AM
1022.CutElasticity	6K	Cricket Graph docu...	Fri, Jun 5, 1992, 10:02 AM
1022.Elasticitygraph	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 9:30 AM
1022.FilmPressgraph	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 9:30 AM
1022.STension400m	6K	Cricket Graph docu...	Mon, Jul 6, 1992, 10:38 AM

109 items | 75.4 MB in disk | 22.2 MB available

	Name	Size	Kind	Last Modified
	1023.CutElasticity	4K	Cricket Graph docu...	Sat, Jul 11, 1992, 11:57 AM
	1023.Elasticitygraph	4K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:12 PM
	1023.FilmPressgraph	2K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:09 PM
	1023.STension400m	4K	Cricket Graph docu...	Mon, Jul 6, 1992, 1:43 PM
▽	102.MS Word	16K	folder	Sat, Jul 11, 1992, 11:58 AM
	1021.MSWord	4K	Microsoft Word doc...	Sat, Jul 11, 1992, 11:42 AM
	1022.MSWord	6K	Microsoft Word doc...	Sat, Jul 11, 1992, 11:43 AM
	1023.MSWord	6K	Microsoft Word doc...	Sat, Jul 11, 1992, 11:58 AM
▽	102.SurfaceTension	—	folder	Sat, Jul 11, 1992, 12:39 PM
	1021.STension240m	4K	Cricket Graph docu...	Mon, Jul 6, 1992, 10:32 AM
	1021.STension400m	4K	Cricket Graph docu...	Mon, Jul 6, 1992, 10:30 AM
	1021.STensionData	14K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:39 PM
	1021.STensiontime	4K	Cricket Graph docu...	Mon, Jul 6, 1992, 1:40 PM
	1021.STensiontimec	4K	Cricket Graph docu...	Mon, Jul 6, 1992, 10:26 AM
	1022.STension240m	6K	Cricket Graph docu...	Mon, Jul 6, 1992, 10:36 AM
	1022.STension400m	6K	Cricket Graph docu...	Mon, Jul 6, 1992, 10:38 AM
	1022.STensionData	20K	Cricket Graph docu...	Mon, Jul 6, 1992, 9:51 AM
	1022.STensiontime	6K	Cricket Graph docu...	Mon, Jul 6, 1992, 1:39 PM
	1022.STensiontimec	6K	Cricket Graph docu...	Mon, Jul 6, 1992, 10:50 AM
	1023.STension240m	4K	Cricket Graph docu...	Mon, Jul 6, 1992, 1:44 PM
	1023.STension400m	4K	Cricket Graph docu...	Mon, Jul 6, 1992, 1:43 PM
	1023.STensionData	20K	Cricket Graph docu...	Mon, Jul 6, 1992, 9:52 AM
	1023.STensiontime	6K	Cricket Graph docu...	Mon, Jul 6, 1992, 1:34 PM
	1023.STensiontimec	4K	Cricket Graph docu...	Mon, Jul 6, 1992, 1:36 PM
▽	10.3	—	folder	Sat, Jul 11, 1992, 1:15 PM
▽	103.Elasticity	—	folder	Tue, Jul 7, 1992, 8:43 AM
	1031.CutElasticity	4K	Cricket Graph docu...	Tue, Jul 7, 1992, 9:01 AM
	1031.Elasticitygraph	4K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:26 PM
	1031.FilmPressgraph	2K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:23 PM
	1031.STension400m	6K	Cricket Graph docu...	Mon, Jul 6, 1992, 3:26 PM
	1032.CutElasticity	4K	Cricket Graph docu...	Fri, Jun 5, 1992, 10:07 AM
	1032.Elasticitygraph	4K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:24 PM
	1032.FilmPressgraph	4K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:22 PM
	1032.STension400m	6K	Cricket Graph docu...	Mon, Jul 6, 1992, 3:33 PM
	1033.CutElasticity	6K	Cricket Graph docu...	Fri, Jun 5, 1992, 10:06 AM
	1033.Elasticitygraph	6K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:25 PM
	1033.FilmPressgraph	4K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:23 PM
	1033.STension400m	8K	Cricket Graph docu...	Tue, Jul 7, 1992, 8:24 AM
▽	103.MS Word	—	folder	Sat, Jul 11, 1992, 12:20 PM
	1031.MSWord	4K	Microsoft Word doc...	Sat, Jul 11, 1992, 12:17 PM
	1032.MSWord	6K	Microsoft Word doc...	Sat, Jul 11, 1992, 12:19 PM
	1033.MSWord	8K	Microsoft Word doc...	Sat, Jul 11, 1992, 12:20 PM
▽	103.SurfaceTension	—	folder	Sat, Jul 11, 1992, 12:42 PM
	1031.Stension240m	6K	Cricket Graph docu...	Tue, Jul 7, 1992, 8:28 AM

Day 10

109 items | 75.4 MB in disk | 22.2 MB available

Name	Size	Kind	Last Modified
1031.STension400m	6K	Cricket Graph docu...	Mon, Jul 6, 1992, 3:26 PM
1031.STensiontime	6K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:56 PM
1031.STensiontimec	4K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:56 PM
1031STensionData	20K	Cricket Graph docu...	Mon, Jul 6, 1992, 2:23 PM
1032.STension240m	6K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:46 PM
1032.STension400m	6K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:50 PM
1032.STensionData	24K	Cricket Graph docu...	Mon, Jul 6, 1992, 2:25 PM
1032.STensiontime	6K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:55 PM
1032.STensiontimec	6K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:58 PM
1033.STension240m	8K	Cricket Graph docu...	Tue, Jul 7, 1992, 8:30 AM
1033.STension400m	8K	Cricket Graph docu...	Tue, Jul 7, 1992, 8:24 AM
1033.STensionData	32K	Cricket Graph docu...	Mon, Jul 6, 1992, 2:27 PM
1033.STensiontime	8K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:53 PM
1033.STensiontimec	8K	Cricket Graph docu...	Sat, Jul 11, 1992, 12:57 PM
▽ Day10.Supportingdata	—	folder	Tue, Sep 1, 1992, 9:29 AM
2.1.89(1,2,3)	14K	PowerPoint document	Fri, Aug 14, 1992, 4:27 PM
Day10Run1.velocity	4K	Microsoft Word doc...	Fri, Aug 14, 1992, 4:29 PM
Day10Run2.velocity	4K	Microsoft Word doc...	Fri, Aug 14, 1992, 4:30 PM
Day10Run3.velocity	4K	Microsoft Word doc...	Fri, Aug 14, 1992, 4:31 PM
Labelsday10.notebook	24K	Microsoft Word doc...	Wed, Jul 22, 1992, 1:36 PM
wwday10.grf	4K	Cricket Graph docu...	Fri, Aug 14, 1992, 4:36 PM

Special Information

19 items		75.4 MB in disk		22.2 MB available
Name	**Size**	**Kind**	**Last Modified**	
▽ Film Pressure/Area curves	84K	folder	Tue, Sep 1, 1992, 11:03 AM	
FilmPress/Area.composite	10K	Cricket Graph docu...	Tue, Jul 14, 1992, 11:00 AM	
Filmpress/LnA.28	4K	Cricket Graph docu...	Mon, Jul 13, 1992, 3:54 PM	
FP26.MSWord	8K	Microsoft Word doc...	Fri, Aug 14, 1992, 8:11 AM	
FP28.MSWord	8K	Microsoft Word doc...	Fri, Aug 14, 1992, 8:16 AM	
FP29a.MSWord	10K	Microsoft Word doc...	Fri, Aug 14, 1992, 8:21 AM	
FP29b.MSWord	10K	Microsoft Word doc...	Fri, Aug 14, 1992, 8:27 AM	
Parea26.24hrs0920am	6K	Cricket Graph docu...	Fri, Jul 24, 1992, 8:49 AM	
Parea28.18hrs0745am	6K	Cricket Graph docu...	Thu, Jul 16, 1992, 2:33 PM	
Parea29a.18hrs1155am	6K	Cricket Graph docu...	Thu, Jul 16, 1992, 2:34 PM	
Parea29b.18hrs0730am	6K	Cricket Graph docu...	Thu, Jul 16, 1992, 2:34 PM	
SurfTens/area.composite	10K	Cricket Graph docu...	Tue, Jul 14, 1992, 10:13 AM	
▽ Wake Width Data	30K	folder	Tue, Sep 1, 1992, 11:03 AM	
Wake Width (B)	4K	Cricket Graph docu...	Fri, May 15, 1992, 7:51 PM	
Wake Width (B) Ln-Ln	4K	Cricket Graph docu...	Sun, Jul 12, 1992, 8:41 AM	
Wake Width (m)	4K	Cricket Graph docu...	Fri, May 15, 1992, 7:53 PM	
Wake Width (m) Ln-Ln	4K	Cricket Graph docu...	Fri, May 15, 1992, 7:59 PM	
WWLnLnSlope.grf	8K	Cricket Graph docu...	Sun, Jul 12, 1992, 9:47 AM	
wwmeters.grf	6K	Cricket Graph docu...	Fri, May 15, 1992, 8:20 PM	